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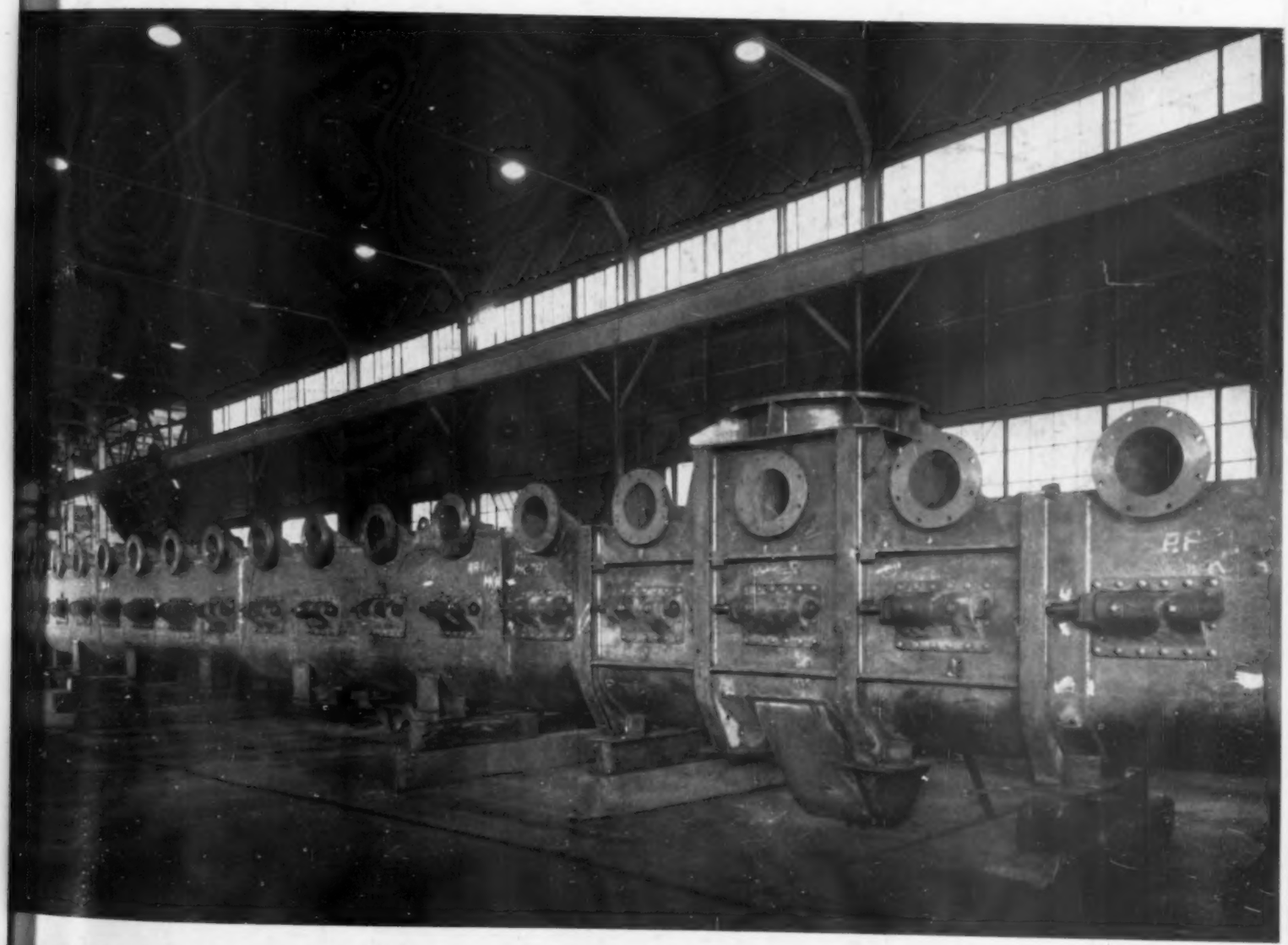

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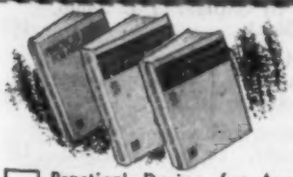

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The Journal of The American Welding Society

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U. S. Navy Developments in Underwater Cutting*

By Bela Ronay and Cyril D. Jensen†

UNDERWATER cutting of metals has been practiced by the Naval Service in connection with salvage and other operations for several decades. Two methods, the arc-oxygen and the oxyhydrogen processes have been in competition throughout this time. The first method originally involved the employment of carbon electrodes in the form of tubes or bars through which oxygen passed and required a d.-c. source of power capable of delivering at least 600 amp. at 50 v. The oxyhydrogen underwater cutting process was developed through evolution from the older oxyacetylene cutting procedure used in air. In course of the evolution, hydrogen replaced the acetylene as fuel and the cutting flame was stabilized by surrounding it with an envelope of air. Oxyhydrogen torches incorporating the latter improvement are being produced commercially today by several reputable manufacturers and have been regarded until quite recently, as the most satisfactory device for the underwater cutting of metal. Meanwhile, owing to the lack of improvement in equipment and method of application, the arc-oxygen procedure came to be regarded as antiquated when compared to the oxyhydrogen process.

Confronted with the need for a simple effective means for underwater cutting, the Navy Department decided early in 1942 to develop the arc-oxygen process to meet the requirements of War's demands. The decision was based partly on the desire to eliminate the need for the highly inflammable hydrogen, the fuel used with the oxyhydrogen process, in that hydrogen is a powerful explosive within a wide range of dilution and is hence a most undesirable deck cargo in times of war. A further undesirable feature of the oxyhydrogen procedure is that the nature and design of the torch tip employed prevents its effective use in a mass of wreckage. Therefore, the Bureau of Ships authorized an investigation to modernize arc-oxygen cutting. The investigation resulted in:

(*a*) New electrode design.
(*b*) New torch design.
(*c*) Simplification of the technique for using the new materials.
(*d*) Standardization of the new procedure.
(*e*) Improved safety features in applying the procedure.
(*f*) Performance equal to that obtainable with oxyacetylene in air.

The modernized arc-oxygen underwater cutting procedure, as adopted by the Navy Department for its purposes, employs covered steel and ceramic tubes as electrodes. The newly developed electrodes are employed with the normally available 300-amp. capacity welding generators or transformers. The oxygen consumption has been considerably reduced from that found necessary with the earlier type of electrodes, while the cutting rate has been many times increased. The power requirement has been approximately halved. The torches now manufactured to accommodate the new type electrodes are not only safe to handle but permit rapid removal and replacement of electrodes independent of the degree of visibility. In the development of new techniques for arc-oxygen cutting, particular attention was devoted to the improvement of safety features for divers. This becomes apparent in the design of the accessories, the required use of a disconnecting switch in the welding circuit, and by the proper dissemination of information concerning these safety features.

Modernization of the arc-oxygen procedure for underwater cutting has been performed at the U. S. Naval Engineering Experiment Station, Annapolis, Md. Field tests of the new materials, equipment and procedure were conducted mostly at the Experimental Diving Unit and Deep Sea Diving School, Navy Yard, Washington, D. C., and at the U. S. Naval Training School (Salvage) Pier 88, New York, N. Y.

The arc-oxygen method of cutting metals is based on the same principle as that employed in oxyacetylene cutting. In the latter, the metal is first locally preheated to incandescence by means of the oxyacetylene flame. When incandescence is reached, a high velocity jet of oxygen is impinged upon the preheated spot. The oxygen jet performs the double duty of oxidizing or burning the core of the preheated portion and removing the products of combustion. As the oxyacetylene cutting torch is moved along the intended line of cut, the diffused heat from the first spot, augmented by the heat supplied by the oxyacetylene flame, continuously advances the incandescent spot in preparation for the action of the oxygen stream. In arc-oxygen cutting, preheating is performed by the electric arc maintained between the material to be cut and the cutting electrode. Since the heat energy available in an arc is much greater than that of an oxyacetylene flame, preheating with the arc-oxygen method is practically instantaneous. Therefore, the instant the arc is established the high velocity oxygen

Fig. 1—Arc-Oxygen Underwater Cutting Torch

* Reprinted from November 1945 issue of *Journal of the American Society of Naval Engineers.*
† U. S. Naval Engineering Experiment Station, Annapolis, Md.

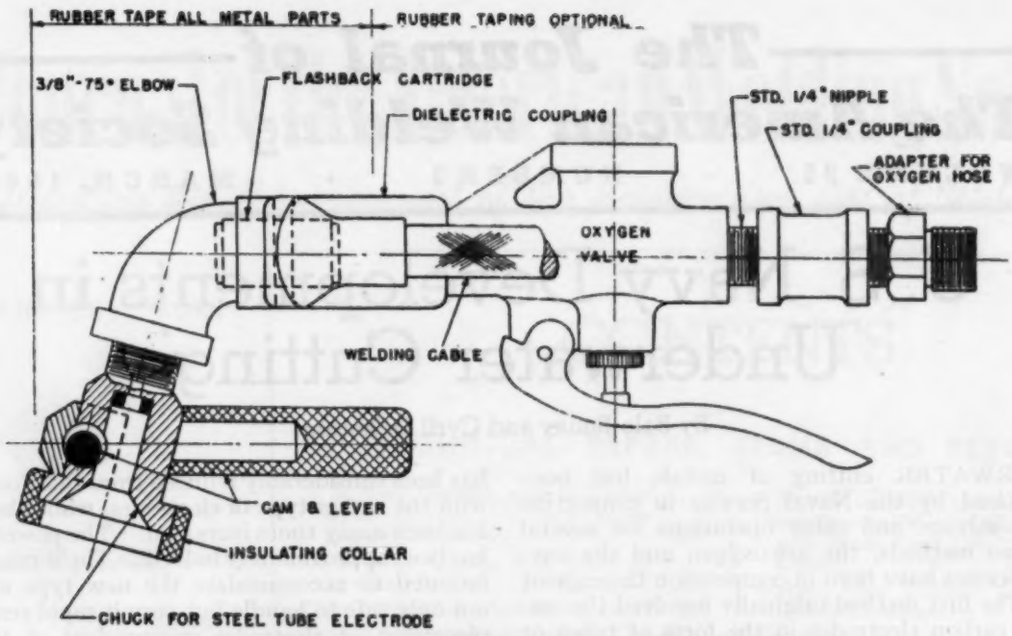

Fig. 2—Cam Action Arc-Oxygen Torch (Left Side View)

stream is admitted to impinge upon the preheated spot where the same phenomena occur as given above for oxyacetylene cutting. Advancing the electrode along the intended line of cut while the electric arc is continuously maintained results in the uninterrupted succession of preheat, oxidation and removal of the burnt metal.

The arc-oxygen process is being employed using either d.-c. or a.-c. power in the arc ciruit. Direct-current power, which is employed at straight polarity, i.e., electrode negative, is preferred for the reason that it is easier to maintain the arc when the electrode is the hot cathode; also, for underwater operations, it is much safer than a.-c. More skill and attention is required with a.-c. power in that during each electric cycle both the current and the voltage drop to zero.

Continuing the analogy between oxyacetylene and arc-oxygen cutting, it is evident that in the latter procedure the arc replaces the oxyacetylene flame and electric power is substituted for the acetylene fuel. The tip of the oxyacetylene cutting torch is merely a multiple orifice nozzle which is outside the combustion zone, and in fact kept cool by the gases flowing through it. Thus the life of the tip of the oxyacetylene torch is not affected by use as long as it is unharmed by mechanical injury. In arc-oxygen cutting the electric arc heats both poles. As the tip of the electrode is one of the poles of the arc, it too is being kept at incandescence and thus exposed to the effects of heat and oxidation.

Steel Tube Electrodes

Since copper base alloys and cast iron do not oxidixe readily, the early users of the arc-oxygen method employed brass and cast-iron electrodes. However, the investigation showed that steel, though readily oxidizable from incandescence, is more suitable by reason of its higher melting point. The steel tube core electrodes specified by the Navy Department for underwater cutting by means of the arc-oxygen process are $^{5}/_{16}$ in. O.D, 14 in. long with a somewhat less than $^{1}/_{8}$-in. bore. These dimensions were evolved empirically and represent the optimum disposition of the available metal for the purpose intended.

The investigation further showed that in order to obtain the desired effects as regards easy starting and maintenance of the arc, it is mandatory that the electrodes be covered. At the present, three types of coverings are being produced commercially on the above cores. One type of covering is produced by extrusion. The composition of this covering is similar to that applied to welding electrodes intended for use in all positions at straight polarity d. c. or with a. c. These electrodes are waterproofed after processing by dipping, the waterproofing material being a thermoplastic lacquer. Another producer processes the steel tubes by multiple dipping, introducing the waterproofing lacquer in the last bath where it also serves as the binder for the mineral components of the covering. A third method of processing the steel tubes is by applying wrappers of plasticized cellulose tape. The plasticized tape is fully waterproofed and, therefore, processing with this material is performed in a single operation. The tape is applied cigarette fashion around the steel tubes. The role and the performance of all of the above coverings

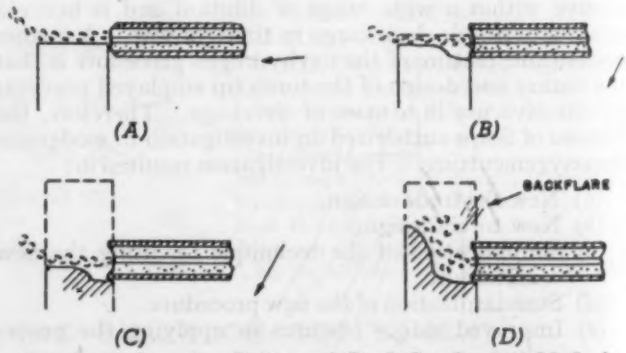

Fig. 3—Underwater Cutting of Steel Arc-Oxygen Method; Steel Tube Electrodes

(A) Press electrode lightly in the direction shown, open oxygen valve and call for "current on." (B) Hold stationary, withdrawing the electrode momentarily if necessary to start the arc. As soon as cut is started for full thickness of the plate change direction of pressure as shown and push more firmly. (C) Continue the light but firm bearing on the electrode as the cutting proceeds, feeding in the melting electrode and maintaining the tip on the lip of the advancing cut. (D) An incomplete cut due to some fault of manipulation is evidenced by backflare. Stop the advance and go back immediately to complete the cut.

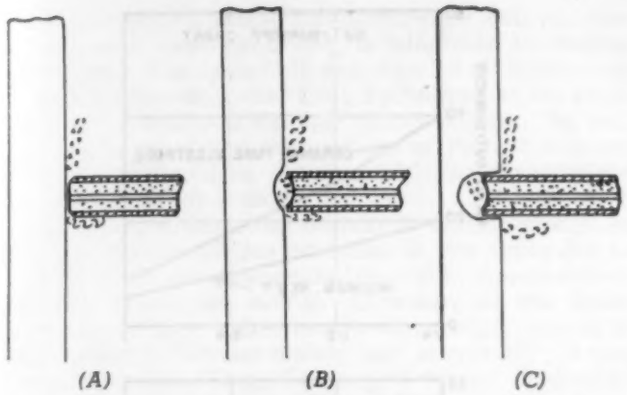

Fig. 4—Punching a Hole Through a Plate, Arc-Oxygen Method; Steel Tube Electrode

(A) Touch the plate lightly at the desired point, open the oxygen valve and call for "current on." (B) Hold stationary for a moment, withdrawing momentarily if necessary to permit melting of the steel tube back inside the covering. (C) Push the electrode slowly into the hole until the plate is pierced.

are identical. The covering must be consumed at a slower rate than the core in order to form and continuously maintain a protecting thimble around the arc; it also must liberate gases to form the bubble wherein the arc is maintained. The covering serves as an electrical insulator, even in the wet condition, to safeguard the diver-operator in the event of accidental body contact while cutting and to prevent arcing from the side of the electrode when working in confined quarters. The covering must be concentrically consumed in cutting to permit restarting the arc, as in welding, should that be necessary. The consumed covering must not form slag on the material being cut in that should slag be deposited in the groove further oxidation would be prevented until the slag is removed.

Regardless of the type of covering used, the service life of a covered, tubular steel underwater cutting electrode averages one minute. It is evident, therefore, that torch design must provide for quick and effortless removal and replacement of electrodes. The torch designed for arc-oxygen cutting, as shown on Fig. 1, consists essentially of a quick opening oxygen valve and the electrode carrying chuck or head. The negative terminal of the electric circuit is attached to the head of the torch. Between the oxygen valve and the head of the torch is a dielectric coupling which serves to shunt out the oxygen valve from the electrical circuit and, thereby, renders it both safe for use as a grip and prevents it from deterioration due to electrolysis. The drawing, Fig. 2, also shows the cam action locking device, and the rubber washer against which the end of the tube is pressed in engagement. The torch further contains a flashback arrester as it has been found that when cutting with steel tube electrodes occasional backflashes take place when the technique is not properly applied. The flashes are somewhat similar to those which occur in oxyacetylene welding when the torch tip is accidentally dipped into the molten pool. The extra flexible lead, generally 10 ft. in length attached to the arc-oxygen torch, is usually of 1/0 size. The lead cables, furnished in 50-ft. lengths, are size 0 and 2/0 depending on the distance between the generator and the diver-operator. The oxygen line used is the standard $^1/_4$-in. oxygen hose.

The rate of oxygen consumption is not critical; satisfactory cutting can be performed within a fairly wide range of oxygen flow. However, applying less than the optimum rate may slow down the operation and, requiring more careful attention, may tire the diver-welder unnecessarily. Using more oxygen than can be utilized within a given plate thickness is of course sheer waste. The following tabulation presents plate thickness-oxygen pressure ratios which were found to be most economical:

Plate Thickness, In.	Oxygen Pressure, Psi.
$^1/_4$	20
$^1/_2$	30
$^3/_4$	40
1	50
More than 1	75 or more

The above values do not include the pressure drop which obtains in a hose more than 50 ft. in length, nor for the mean head of water above the zone of cutting. To compensate for the static head the following empirical formula is used: Topside pressure in psi. $= 0.445 \times H + P$, wherein H is the head of water in feet and P, the pressure given in the above tabulation. No formula is applicable to compensate for loss of pressure due to hose lengths in excess of 50 ft. in that the pressure drop varies with the size and condition of the hose and the number of kinks in the line.

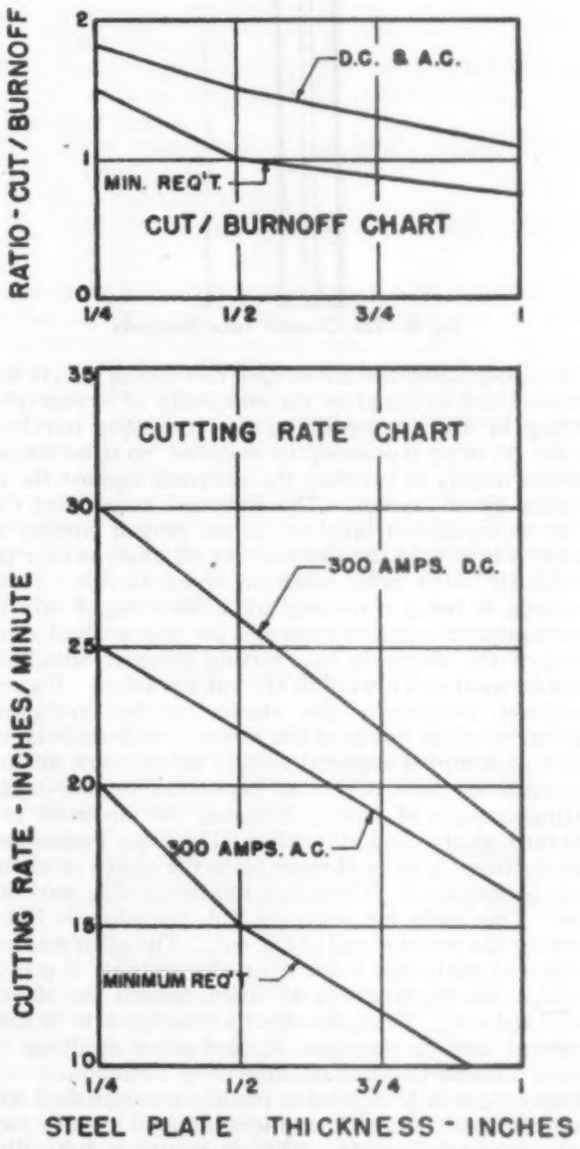

Fig. 5—Underwater Cutting Arc-Oxygen Method. $^5/_{16}$-In. Diam. Steel Tubular Electrodes with a Commercial Extruded Covering

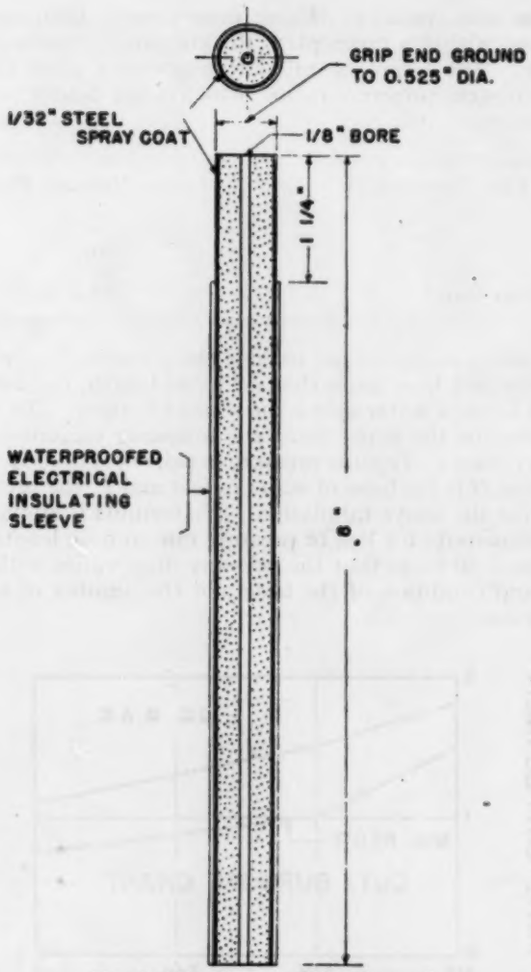

Fig. 6—The Ceramic Tube Electrode

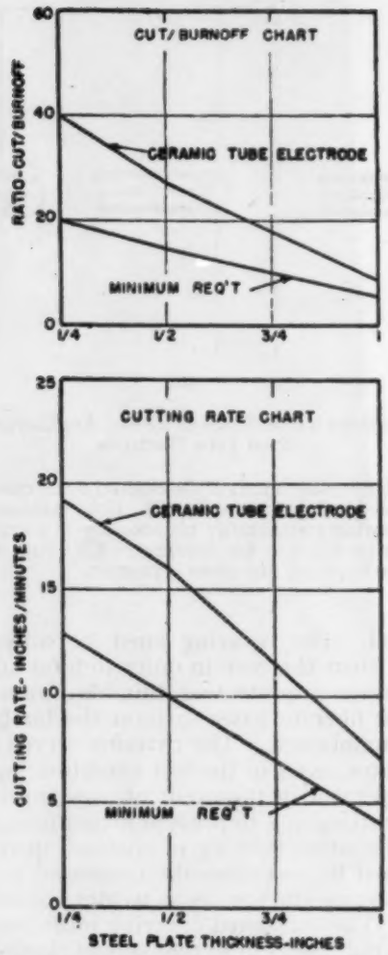

Fig. 7—Typical Performance Chart, Ceramic Tube Electrode

In modernizing the arc-oxygen method all efforts were concentrated to simulate the simplicity of oxyacetylene cutting in air. Accordingly, the technique developed for the arc-oxygen process, the so-called "drag technique" consists merely of pressing the electrode against the advancing lip of the cut. The only task resembling electrode manipulation involved in arc-oxygen cutting underwater is to hold the electrode at all times as near perpendicular to the metal being cut as practicable. As the electrode is being consumed at a fairly rapid rate the diver-operator must compensate for the gradual shortening of the electrode by exerting pressure simultaneously forward and inward as the cut advances. Figure 3 illustrates graphically the above-described technique. The outstanding virtue of the above simple technique is that no attempt is required to hold an arc as in welding. Inasmuch as the modernized procedure for arc-oxygen cutting consists of merely dragging the electrode as it cuts through the steel, it is called "The Drag Technique."

In cutting 1/4 in. or thinner plate the above procedure must be modified. There are two applicable modifications. One calls for reducing the pressure to barely touching the metal ahead of the cut. The other method, which is of particular value when the visibility is poor, is to point the electrode at 45° back toward the already completed cut. Thus, the effective thickness to be cut is increased and cutting can be performed applying the normal pressure required with the Drag Technique.

Punching a hole in steel is readily accomplished with steel tube electrodes. The process is rapid and the technique extremely simple. The procedure is fully illustrated on Fig. 4. By this method 3-in. diameter steel shafting has been pierced without difficulty.

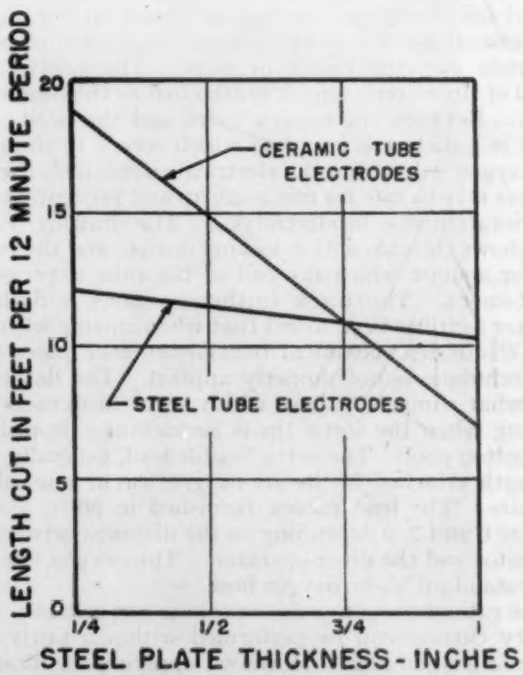

Fig. 8—Comparison of Cutting Rates for a 12-Min. Cutting Period

The arc-oxygen method of underwater cutting, employing steel tube electrodes, is adaptable to cutting steel in air. The applicable technique for all thicknesses of plate may be either the "Drag Technique" as described above or a short arc technique as in welding. The cutting rate is rapid and the neatness of the cut is intermediate between those obtained with the oxyacetylene and the carbon arc methods.

The above descriptions pertain to cutting steel. In addition, the arc-oxygen procedure is also applicable to cutting, in air or underwater, cast iron, stainless steel and the nonferrous metals. However, as the latter materials do not oxidize readily the cutting process is slow in that it becomes mainly that of melting. It was found that the "Drag Technique" is not applicable. The investigation further showed that in cutting brass or bronze, air may be substituted for oxygen but that in cutting cast iron some advantage is derived through retaining the oxygen. By reason of the apparent sluggishness of the metal, which melts only in the immediate sphere of the arc, it is necessary to melt out the metal in layers which requires constant manipulation of the electrode in and out of the cut. This manipulation also helps to push out the molten metal which is not blown out by the oxygen or air stream. However, when the above metals to be cut are only $^1/_4$ in. thick or less, they can be parted by arc-oxygen cutting, employing the first of the techniques given above for parting thin steel plates.

The performance of arc-oxygen cutting electrodes is determined by cutting underwater steel plates of $^1/_4$, $^1/_2$ and 1 in. thickness. The requirements for suitability of 14 in. long, $^5/_{16}$ in. diameter, 0.112-in. bore steel core underwater cutting electrodes are based on obtaining the following minimum cutting rates and cut-burnoff ratios:

Minimum Requirements

Plate Thickness, In.	Oxygen Pressure, Psi.	Cutting Rate, In./Min.	Cut-Burnoff Ratio
$^1/_4$	20	20	1.5
$^1/_2$	30	15	1.0
1	50	8	0.75

The term cut-burnoff ratio given above is applied to define the ratio of the length of the cut obtained for each inch of the electrode consumed. Under Laboratory conditions the cutting rates and cut-burnoff ratios are much more favorable than indicated in the above tabulation. Figure 5 gives typical results obtained in the course of inspection tests. Thus a single electrode when consumed to a 2-in. stub will cut, under laboratory conditions, 21 in. of $^1/_4$-in. plate or 13 in. of 1-in. plate, all in a period of slightly less than a minute.

Analyzing the performance of covered steel tube underwater cutting electrodes the following advantages become evident:

(*a*) Simple technique, ease of operation.

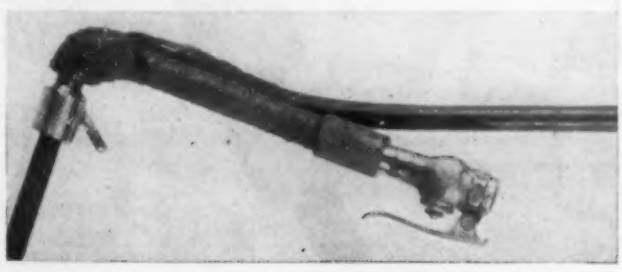

Fig. 9—Torch Used for Removing Austenitic Weld Metal

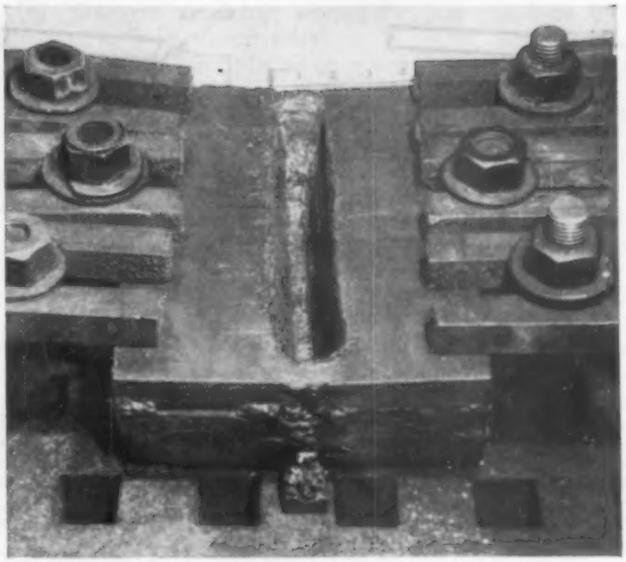

Fig. 10—Austenitic Weld Metal Removed in 3-In. Plate Assembly

(*b*) Rapid rate of cutting.
(*c*) Neat, trim cuts.
(*d*) Power requirement within the capacity of a 300-amp. welding generator or transformer.

Disadvantages are:

(*a*) Short electrode life, requiring frequent replacement.
(*b*) Low cut-burnoff ratio.
(*c*) Narrowness of kerf removed renders inspection difficult.

The short life of the covered steel tube electrodes is a serious disadvantage under many conditions occurring in underwater cutting operations. Likewise, the neat, narrow kerf removed by these electrodes may be a handicap when the diver-operator inadvertently fails to cut through at one or more points. The narrowness of the gap prevents an easy, direct method of locating the uncut part by feeling, which is the only method of inspection available in underwater cutting. To overcome the above shortcomings and as a complement to the covered steel tube electrodes another type has been developed, namely, the covered ceramic tube, underwater, arc-oxygen cutting electrode.

Ceramic Tube Electrodes

The core of the ceramic tube electrode is, as the name implies, a ceramic material composed of highly refractory, stable oxides. This nonmetallic substance was chosen for the following reasons:

(*a*) Being a high grade refractory, its melting point is materially higher than that of steel.
(*b*) Being composed of stable oxides, it is not affected by the oxygen stream.
(*c*) It is an electrical conductor.

The core of the ceramic tube electrode is $^1/_2$ in. in diameter, 8 in. long with an $^1/_8$-in. bore. The core tube is processed first by a high-temperature heat treatment which renders it resistant to thermal shock. The inherent brittleness of the ceramic product is almost fully compensated by the $^1/_{32}$-in. thick mild steel shroud which is applied for the full length of the electrode by metal spraying. Finally, the tube is wrapped by an electrical insulating sleeve and further covered with

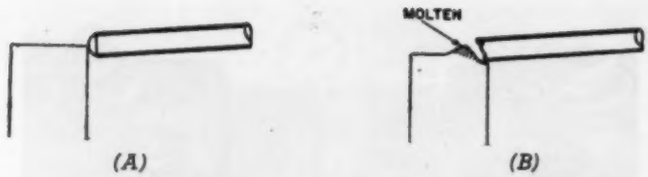

Fig. 11—Metallic Arc Cutting of Thick Plate

(A) Hold electrode tip in light contact with edge of plate and call for "current on." (B) Withdraw the tip momentarily then advance the electrode slowly across the edge of the plate, maintaining near contact between electrode and plate. (C) The enlarging pool of molten metal is pushed to the edge of the plate. (D) And shoved off whereupon the electrode tip is immediately returned to the near edge for the next stroke.

waterproofing. One end of the steel shroud, for the length of $1^1/_4$ in. is ground to 0.525 in. diameter to serve as the grip end, as shown on the sketch on Fig. 6.

Ceramic tube electrodes are employed with the same power sources as the steel tube material. However, while the power input is approximately the same for the steel and the ceramic tube electrodes, the latter should be operated at 350 amp. at 30 v. d. c., straight polarity or a. c. Although the bore of the ceramic tubes is slightly larger than that of the steel tubes, the same oxygen pressure are applicable with both types. The cutting technique used with the ceramic tube electrodes is a modification of that developed for the covered steel tubes, and differs in the respect that the ceramic tubes are applied with a light touch. The kerf removed in cutting with ceramic tube electrodes is not as clean as with steel tubes, however, it has the merit of width. For $^1/_2$-in. plate and less the diver-operator is able to reach through with his gloved hand to inspect the fullness of the cut. Typical cutting rates and the burn-off ratios obtained in inspection tests of ceramic tube electrodes are shown on the graph on Fig. 7. The head of the arc-oxygen cutting torch originally developed for use with the $^5/_{16}$-in. diameter covered steel tube electrodes is detachable and is replaceable by another whose bore accommodates the ceramic electrodes.

The specified minimum performance for ceramic electrodes is as follows:

Plate Thickness, In.	Oxygen Pressure, Psi.	Cutting Rate, In./Min.	Cut-Burnoff Ratio
$^1/_4$	20	13	20
$^1/_2$	30	10	15
1	50	4	5

A direct comparison between the cutting-rate graphs on Figs. 5 and 7 should not be made owing to the fact that the rates shown on Fig. 5 do not include time to change electrodes and to regain the arc. For a comparative study of the cutting rates obtainable with the steel tube and the ceramic tube electrodes the logical time interval to be used is 12 min. which is the approximate average life of a ceramic tube electrode. During the course of 12 min. of cutting with steel tube electrodes it may be assumed that approximately 8 electrodes will be consumed, the remaining time being used in changing electrodes and regaining the arc. On the basis of the above conditions Fig. 8 is presented with the understanding that it is an approximation only as the skill of the operator and the adversity of the diving conditions play a most important part in the rate of underwater cutting.

A review of the performance graphs on Fig. 8 indicates that the ceramic tube underwater arc-oxygen cutting electrodes outperform steel tubes in cutting thin and medium thick steel plates. The graphs further indicate that steel tube electrodes, regardless of their short life, are more efficient in cutting steel over $^1/_4$ in. in thickness. The latter electrode performs better with a.-c. than the ceramic electrodes. However, the ceramic electrodes offer additional advantages which are not evident from the performance charts, namely:

(*a*) Better maneuverability in confined places owing to their 8-in. over-all length and long life.

(*b*) The light weight of the ceramic tube electrode. One hundred ceramic tubes weigh only 24-lb. packed for plane transport. This amount is sufficient to do the work of from 800 to 1000 steel tube electrodes weighing approximately 250 lb.

Ceramic tube electrodes are also suitable for underwater cutting of stainless steel, copper and nickel base alloys and cast iron using the technique described above in connection with the steel tube electrodes. In addition, ceramic tubes can be used advantageously for cutting steel and the above listed metals in air. A recent development is the technique for removing defective austenitic weld metal from deep grooves in any position. The above development is of particular value for the removal of defective austenitic weld metal from deep groove joints in the flat position. The removal of defective austenitic weld metal cannot be readily effected by chipping for the reason that austenitic steel work-hardens. The often applied procedure of removing the defective austenitic weld metal by grinding, is a costly operation both in labor and materials. A fast and

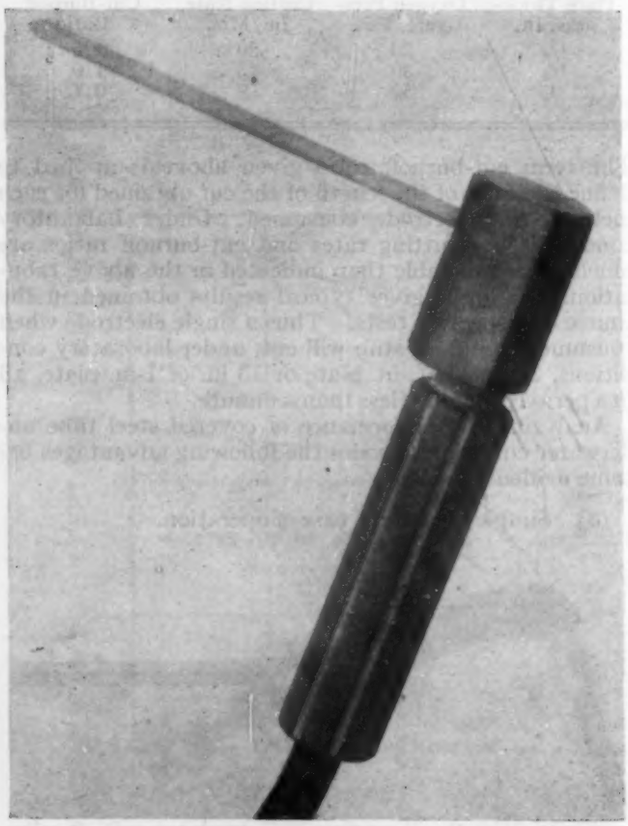

Fig. 12—Insulated Underwater Electrode Holder

economical method for removing defective austenitic weld metal (developed by the New York Shipbuilding Corp.) employs the carbon arc as a source of heat and an air jet to blast out the molten metal. However, the application of this procedure for fixed flat joints calls for the use of minimum 600 amp. and further, as the procedure involves the simultaneous manipulation of the arc and an air jet, it requires a high degree of skill. The procedure for removing defective austenitic steel weld metal from fixed flat joints with ceramic tube electrodes is considerably slower than with the carbon arc method. However, it has the merit of requiring but 300 amp. at about 20–30 v., oxygen at 3 psi., of being extremely simple in operation, and of being controllable, that is, there is no danger of suddenly cutting deeper or wider than desired. The details of the technique for removing defective austenitic weld metal from joints fixed in any position using ceramic tube electrodes are described in the following:

Equipment Required

(*a*) Special type electrode holder, whose details appear on Fig. 9.

(*b*) Oxygen regulator, secondary, low pressure 0–5 or 0–15 psi. capacity.

(*c*) Water bucket placed on a board or other insulating material.

(*d*) Ceramic tube electrodes, metal sprayed, but without the insulating wrapper.

Technique

The technique evolved in the use of the ceramic tube cutting electrode for removing austenitic weld metal is extremely simple, requiring no special skill or aptitude. It is not a melting or puddling in the sense metallic or carbon electrodes are applied to remove weld metal when the welded joints are positioned in the vertical or overhead positions; further, it is not similar to arc welding in that no arc is maintained by careful manipulation of the electrode. The operation is simply rubbing the ceramic electrode back and forth over the area where the weld metal is to be removed. The operation is performed blockwise or progressively, removing only a portion of the weld metal in successively worked increments. The incremental length is also optional with the operator. The operation consists of rapid back and forth recipro-

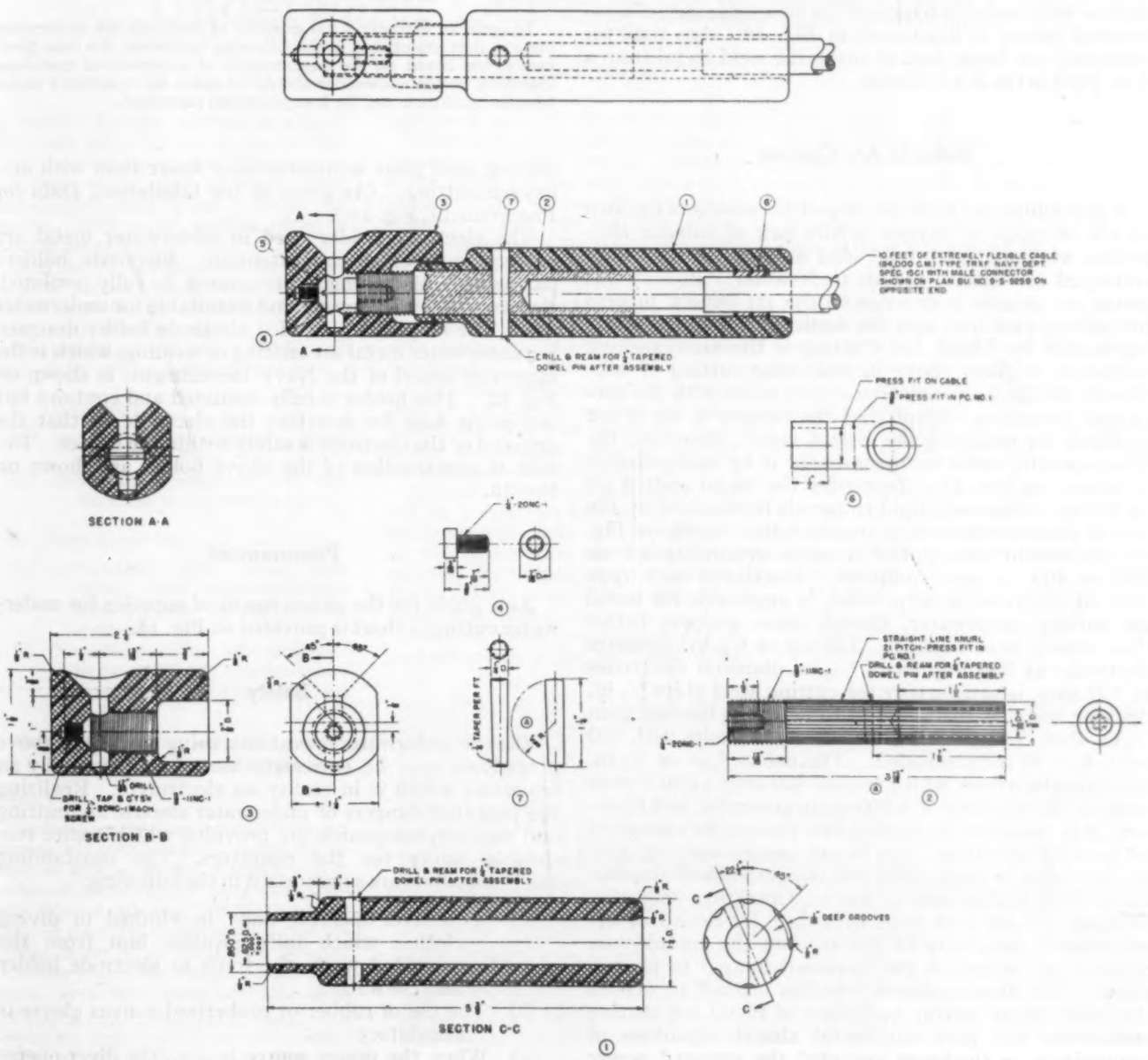
SECTION A-A
SECTION B-B
SECTION C-C
DRILL & REAM FOR ⅜" TAPERED DOWEL PIN AFTER ASSEMBLY
10 FEET OF EXTREMELY FLEXIBLE CABLE (84,000 C.M.) TYPE TRXF NAVY DEPT. SPEC. 15C1 WITH MALE CONNECTOR SHOWN ON PLAN BU. NO. 9-S-9259 ON OPPOSITE END
PRESS FIT ON CABLE
PRESS FIT IN PC. NO. 1
STRAIGHT LINE KNURL 21 PITCH - PRESS FIT IN PC. NO. 1
DRILL & REAM FOR ⅜" TAPERED DOWEL PIN AFTER ASSEMBLY
DRILL & REAM FOR ⅜" TAPERED DOWEL PIN AFTER ASSEMBLY
DEEP GROOVES

Fig. 13

cating strokes at a rate of 5 to 10 per second, dependent on the length of the strokes, with the electrode held perpendicular to the work, the tip of the electrode being in light contact with the work. If the operator chooses he may accomplish the desired result by describing a circular pattern provided that he maintains the same speed of travel as in reciprocating. None of the above details of the technique are critical in that the operator is guided by the results obtained. The technique is correct when the weld metal melts forming balls or pellets which rapidly multiply with each stroke. After about one minute's continuous rubbing of an increment so many pellets are formed that they begin to interfere with the ease of operation; also, the tip of the ceramic electrode becomes very hot. Then the operator stops and places the electrode and holder in a bucket of water mounted on a board or equivalent material as regards electric insulation. As the operator resumes his work on another increment, the chipper removes the balls and pellets preferably by use of a pneumatic tool. The above-described routine of rubbing with the ceramic electrode and cleaning with a pneumatic tool is repeated, melting off layers of weld metal averaging $^1/_{16}$ in. in thickness per operation until the desired volume of defective weld metal is removed. The appearance of a so-cleaned groove is illustrated in Fig. 10. Arc time for removing one linear foot of austenitic weld metal from a 1-in. joint in the flat is 45 min.

	UNIT	NO. OF ELECTRODES APPROX	STEEL PLATE CUT IN FT/BOX OF ELECTRODES			
			1/4" THICK	1/2" THICK	3/4" THICK	1" THICK
ARC-OXYGEN CUTTING	50 LB BOX	187	240	170	170	160
COMMERCIAL STEEL TUBE ELECTRODES	TANKS OF OXYGEN (200 CU FT) PER BOX OF ELECTRODES		2.7	2.0	2.0	2.0
ARC-OXYGEN CUTTING	6 1/2 LB BOX	25	475	375	275	175
CERAMIC TUBULAR ELECTRODES	TANKS OF OXYGEN (200 CU FT) PER BOX OF ELECTRODES		6	6	6	6
METALLIC ARC CUTTING 1/4" ELECTRODES-14" LONG-400 AMPERES	50 LB BOX	220	176	77	44	VARIABLE
METALLIC ARC CUTTING 3/16" ELECTRODES-14" LONG-400 AMPERES	50 LB BOX	410	307	135	58	VARIABLE
METALLIC ARC CUTTING 3/16" ELECTRODES-14" LONG-300 AMPERES	50 LB BOX	410	185	102	VARIABLE	VARIABLE

Fig. 14—Data for Procurement

To assist in estimating the quantity of materials for underwater cutting, data are offered in the following tabulation, the data given herein are based on the performance of experienced operators, therefore, ample allowances should be made for operations under adverse conditions and for inexperienced personnel.

Metallic Arc Cutting

A procedure has been developed for emergencies such as the shortage of oxygen or the lack of tubular electrodes, where covered, mild steel welding electrodes are employed for cutting metals underwater. In fact this metal arc process is superior to the arc-oxygen process for cutting cast iron and the nonferrous metals. Parting metals by Metal Arc Cutting is the same melting operation as given above in describing cutting of nonferrous metals, cast iron or stainless steels with the arc-oxygen procedure, except that the oxygen or air is not available for removing the molten metal; therefore, the diver-operator must compensate for it by manipulation as shown on Fig. 11. To render the metal melted off by the arc sufficiently fluid to permit its removal by the simple short-stroke sawing manipulation shown on Fig. 11, the current rate applied in metal arc cutting is from 250 to 400 or more amperes. Practically any type covered electrode, waterproofed, is applicable for metal arc cutting underwater, though some perform better than others, as in welding. The use of $^5/_{32}$-in. diameter electrodes at 300 amp. or of $^5/_{32}$-in. diameter electrodes at 250 amp. is satisfactory for cutting steel plate $^1/_4$ in. thick or less. If the material to be cut is heavier than $^1/_4$ in. then the use of $^5/_{16}$- or $^1/_4$-in. electrodes with 400 amp. d. c. is recommended. The use of $^5/_{16}$- or $^1/_4$-in. diameter electrodes, which require 400 amp. at 40 v. may overtax the capacity of a 300-amp. generator and therefore, it is advisable to employ two generators connected for parallel operation. As in arc-oxygen cutting, a.-c. power source is applicable, but dangerous and requires about 10% higher current rates. Operation with a. c. demands greater skill than with d. c. by reason of the pronounced instability of the arc and the greater care required by reason of the increased hazard to electric shock. The diver-operator who has learned to master the short stroke sawing technique of metal arc cutting underwater can part any metal almost regardless of composition or thickness provided the required power source is available. The rate of progress obtained in cutting steel plate is substantially lower than with arc-oxygen cutting. (As given in the tabulation, Data for Procurement, Fig. 14.)

The electrode holder used in underwater metal arc cutting requires special attention. Electrode holders particularly the prong types cannot be fully insulated, therefore, they are unsafe and unsuitable for underwater use. The all-plastic, shielded electrode holder designed for underwater metal arc cutting or welding, which is the approved model of the Navy Department, is shown on Fig. 12. This holder is fully insulated and contains but one single hole for inserting the electrode so that the grip end of the electrode is safely within the holder. Details of construction of the above holder are shown on Fig. 13.

Procurement

As a guide for the procurement of supplies for underwater cutting a chart is provided on Fig. 14.

Safety

Electric underwater operations, using any of the above procedures may be extremely hazardous, especially in sea water which is in reality an electrolyte. Realizing the potential dangers of underwater electric arc cutting and welding, safeguards are provided which assure reasonable safety for the operators. The outstanding safety measures are summarized in the following:

(*a*) The diver-operator must be clothed in diving clothes which fully insulate him from the grounded work, the torch or electrode holder and the water.

(*b*) The use of rubber or rubberized canvas gloves is mandatory.

(*c*) When the power source is a. c., the diver-operator's head must be insulated from the helmet

by wearing a woolen skull cap or cloth "beanie." The exhaust valve button must be insulated by rubber tape or any other fully reliable means.

(*d*) No part of the submerged portions of the lead cables shall be left uninsulated. The torch or electrode holder must be the approved type and if in an emergency a substitute device is used, it too must be fully insulated.

(*e*) The use of a manually or preferably a magnetically controlled disconnecting switch in the *welding circuit* is mandatory to safeguard the diver-operator. To make these devices effective the diver-operator must follow the following rules:

(1) On inserting theelectrode in holder, the diver-operator is to locate the starting point, hold the electrode against the work and when fully poised and ready to cut, signal for "Current On."

(2) On having consumed the electrode the diver-operator shall not attempt to remove the stub until the request "Juice Off" has been confirmed by the tender, who does not confirm the request until the circuit has been broken by him, i.e., after the switch has been opened.

(3) The diver-operator shall be warned never to hold the torch or electrode holder in such manner that the electrode is pointing toward him, for that condition may entail about the same danger as holding a loaded pistol pointed toward his body.

(*f*) Tests showed that in all underwater metal arc operations hydrogen and CO gases are generated. Should these gases be entrapped within closed compartments they may constitute explosion or asphyxiation hazards or both. Therefore, it is mandatory that the compartment directly above zones of underwater arc-oxygen or metal arc operation be properly vented.

Underwater Cutting and Welding*

By Chas. Kandel†

UNDERWATER cutting as applied here refers to the process of cutting metals of any thickness at any depth under water to which divers may descend, using oxygas or electric arc process. Underwater welding refers to metallic arc process.

Steel can be cut with ease and at a speed equal to surface cutting. Cast iron and nonferrous metals can also be cut, but at a somewhat reduced speed.

The following are the most widely used methods for cutting metals under water:

1. Gas cutting:

(*a*) Oxyacetylene—limited to a depth of less than 20 ft.

(*b*) Oxyhydrogen—suitable for any thickness at any depth.

2. Electric cutting:

(*a*) Arc-oxygen: with carbon electrodes; with tubular steel electrodes; with tubular ceramic electrodes.

(*b*) Metallic arc with a solid steel electrode of suitable characteristics —limited in speed and thickness of metal.

Underwater welding with the metallic arc is the only process in use at this time.

History

Underwater cutting of metals with gas torches has been known in theory for almost as long as surface cutting. But it remained dormant until 1925, when Captain Edward Ellsberg, U.S.N., developed the first practical torch and used it in the raising of the U. S. Submarine S-51 the following year. The equipment and technique were first made available on a commercial basis in 1927 by Craftsweld.

Underwater cutting with the carbon arc and oxygen has been in use for a somewhat longer period but has since become more or less obsolete. Underwater cutting with tubular steel electrodes has become a routine operation with the armed forces during the last few years as a result of developments and collaboration between the U. S. Navy and manufacturers of equipment and electrodes. Underwater cutting with tubular ceramic electrodes is also being used.

Underwater cutting with solid steel electrodes is a process of long standing but of limited use even with electrodes of improved characteristics such as have become available in recent years.

Although underwater metallic arc welding has been known for over 15 years, it has attained the ranks of a standard process on mild steel joints only in recent years following development work carried on by the U. S. Navy in conjunction with manufacturers of welding equipment.

In all of these it is now possible to obtain commercially the specialized equipment, supplies and accessories and, to a limited extent, qualified divers who are skilled operators. The work can be planned in the usual way, knowing in advance just what is required in the way of equipment, tools, gases and rod as well as the man-hours to do a specific job.

1. Gas Cutting

A. Oxyacetylene cutting underwater is limited to a depth of less than 20 ft. because acetylene becomes unstable when used at a pressure over 15 psi. Acetylene gas is generally not recommended for underwater cutting.

B. Oxyhydrogen, on the other hand, may be used for any thickness at any depth.

The basic principles of an underwater gas cutting torch are very simple. The fuel gas used, whether acetylene or hydrogen, requires two parts of oxygen for complete combustion.

One part is supplied in the form of pure oxygen, delivered to the torch under proper control from the oxygen cylinder or a similar source.

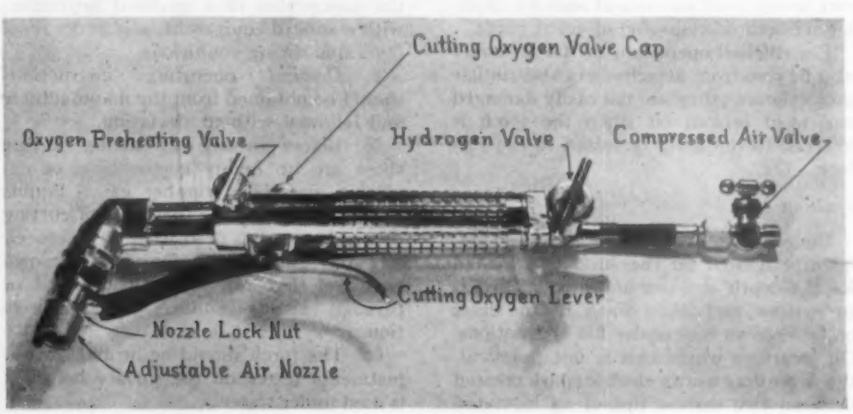

Fig. 1—Craftsweld Oxyhydrogen Underwater Cutting Torch (Ellsberg Model)

* This chapter on underwater cutting and welding was prepared at the request of the author of *Audels Welders Guide*.

† President, Craftsweld Equipment Corp., Long Island City, N. Y.

Fig. 2—Craftsweld Arc-Oxgyen Fully Insulated Underwater Cutting Torch (Kandel Model)

The other part of oxygen is obtained from the atmosphere surrounding the flame at the end of the tip. Since there is no air under water, the deficiency is made up by creating an artificial atmosphere around the tip by means of an air jacket and delivering to it a supply of compressed air from a suitable source on the surface.

For efficient operation, however, the discharge end of the air nozzle must be designed to supply the compressed air without creating turbulence and without contaminating the purity of the oxygen delivered through the central orifice of the tip. Turbulence will interfere with preheating, while a reduction of the purity of the oxygen by contamination with compressed air will reduce the cutting speed and, if carried far enough, may even make any cutting impossible.

An underwater cutting torch is subject to more rigorous working conditions than a surface torch because of its exposure to the erosive and corrosive action of mud, sand, oil and other chemicals frequently present below the surface. When the valves are closed before returning the torch to the surface, the water and its impurities will back into the torch.

An underwater cutting torch must, therefore, be made of tough, noncorrosive metals exclusively and, in addition, must be so constructed as to allow easy and direct access to all valves and seats for cleaning without dismantling adjacent parts.

For efficient operation, the torch should also be free from attachments and similar projections as they are too easily damaged and even broken off when the torch is lowered to the diver or raised to the surface.

Ignition

Underwater gas torches are most frequently ignited on the surface, adjusted for the depth of water at which cutting is to be done, and taken down by the diver or lowered to him under his instructions. On locations where this is not practical, the diver may use an electric spark created between two carbon tips of an insulated holder connected to a supply of current on the surface. A pneumatic type spark lighter or a chemical capsule has also been used.

A complete gas underwater cutting outfit will generally include the following:

1. An underwater cutting torch. See fig. 1.
2. A supply of oxygen gas in cylinders manifolded together.
3. A suitable oxygen regulator.
4. High-pressure oxygen hose.
5. A supply of hydrogen gas in cylinders manifolded together.
6. A suitable hydrogen regulator.
7. High-pressure hydrogen hose.
8. A supply of compressed air of adequate pressure and volume.
9. High-pressure compressed air hose.
10. A complete diving outfit equipped with loudspeaker telephone.

Safety Precautions

In addition to the standard practice followed in the use of all gas welding and cutting equipment, the following are recommended in the interest of safety and best performance:

1. Only a qualified diver assisted by an experienced tender and a trained torch man should use underwater equipment.
2. The diver should be a qualified operator on the surface before taking training under water.
3. The training should be given under the supervision of a qualified instructor, with standard equipment, and under most favorable diving conditions.
4. *Detailed* operating instructions should be obtained from the manufacturer and followed without deviation.
5. Before starting any cutting, be sure there are no highly combustible or explosive materials, whether gases, liquids or solids, adjacent to the point of cutting or within a radius of at least 30 ft, especially overhead. Sparks have been known to travel that far, especially upward or through existing channels in other direction.
6. The torch should be lit and the adjustments tested on the surface before it is used under water.
7. At the end of each day's work, the torch should be cleaned thoroughly and dried inside and outside, including the oxygen high-pressure valve, seat and spring.
8. Owing to the difficult footing and poor visibility usually prevailing under water, the diver should handle the torch with care, stay completely clear of the torch hose and avoid excessive slack in the lines.
9. The orifices in the cutting tips should be kept clean but care should be used in cleaning them so as not to distort or enlarge them.
10. The oxygen regulators used should be adequate for the delivery of the needed volume without freezing.
11. The diving gear used should be in good condition and should be equipped with a loudspeaker telephone designed for uninterrupted two-way communication. A trained torch attendant should be on duty continuously on the surface at the oxygen and gas regulators.
12. No work of any kind should ever be permitted on the surface over the space in which the diver is working within a radius less than the depth of operations.

2. Electric Cutting

A. Arc-oxygen

The basic principles of arc-oxygen cutting are simple, *combining the use of the electric arc as a source of heat, with pure oxygen under pressure* as a means of rapidly oxidizing the molten metal.

Tubular electrodes are employed and the oxygen is delivered through the bore of the electrode.

The electrode may be a carbon or graphite rod, with one or more metal tubes in it, or a hollow ceramic rod, or a covered steel tube. Regardless of the type, it must be fully insulated and thoroughly waterproofed.

Hollow Carbon Electrode.—Arc-oxygen cutting with the carbon or graphite type of electrode although known for more than 20 years has given way to a large extent to more effective and improved gas cutting methods and to easier-to-use tubular steel electrodes.

The cored carbon electrode is about $^{3}/_{8} \times {}^{3}/_{4}$ in. in cross section and has one or more metal tube cores along its length for transmitting the oxygen under pressure to the arc. It is 12 in. long and uses from 600 to 1000 amp. It lasts about 20–30 min. in operation. After it is consumed, the torch must be returned to the surface where the insulation is cut away, a new electrode screwed into position and the electrode and front end of the torch carefully taped with several layers of rubber and friction tape before the torch is returned to the diver.

Tubular Steel Electrodes.—For a number of reasons, this type of electrode is now widely used by the armed forces in underwater salvage work. Its use can be quickly taught. Electrodes as well as holders are commercially available. Changing of electrodes under water is easily accomplished. The process can be employed under water not only for cutting steel, but also for cast iron and nonferrous metals. It may also be used in the open air for the cutting of difficult high-alloy steels such as the stainless group cast iron and nonferrous metals.

The electrode itself is a steel tube with an extruded and waterproofed coating. At present, it is available in only one size which is $^5/_{16}$ in. O.D. and 14 in. long. Eventually, tubular steel rods for arc-oxygen work may become available in a number of sizes.

The electrode is inserted into the torch head and locked and sealed by taking a quarter turn on the lock nut. When the electrode is consumed, the lock nut is given a reverse quarter turn and the stub is blown out by depressing the oxygen valve lever.

Tubular Ceramic Electrodes.—These electrodes consisting of hollow rods of silicon carbide or some other ceramic material are generally $^1/_2$ in. in diameter and 8 in. long.

In general, they are used in the same way as tubular steel electrodes and with a similar type of torch or holder, except that the torch must be equipped with a larger collet to accommodate the $^1/_2$-in. diameter rod.

Each electrode will burn for a period of about ten minutes, so that not as much time is lost in changing electrodes as with the more rapidly consumed steel rods. Also, because of the larger cross section, heavier currents may be used. However, careful handling is required to avoid breaking the electrode when changing rods or working in awkward places.

B. Metallic Arc Cutting with Solid Steel Electrodes

Solid steel electrodes with extruded and waterproofed coatings may also be used for underwater cutting. Such electrodes are available commercially in a complete range of sizes; the $^5/_{16}$- and $^1/_4$-in. diameters will operate successfully in cutting plate up to $^3/_4$ in. in thickness.

Equipment the same as that used for underwater welding is employed. The Craftsweld arc-oxygen underwater cutting torch may also be used for the purpose by removing the collet used with the tubular steel electrode and replacing it with a collet of correct dimensions. This change may be made very readily by the diver under water.

A fully insulated arc-oxygen underwater cutting torch, such as is used in this process (shown in Fig. 2) consists of a head to which the power cable is connected directly. Midway on the underside of this head is attached a dielectric coupling for insulating the head from the rest of the torch. To this coupling is attached the oxygen control valve, lever operated, and the oxygen supply hose connected at its inlet.

At the front end of this torch head is a collet type electrode grip with provisions for sealing the inlet end of the tubular electrode to the oxygen supply with the same insulated lock nut which locks the collet around the electrode.

The interior of the torch head is equipped with a screened flash arrester cartridge (inserted from the front) which absorbs the force and heat of the flash, dissipates its effect, and protects the torch from damage. The cartridge can be readily removed for cleaning or replacement by the diver under water. The collet lock nut, the torch head and the torch insulator coupling are fully insulated with dielectric jackets made of materials not affected by water, oil, acids, alkalis or spatter.

A complete arc-oxygen underwater cutting outfit will generally include the following.

1. A fully insulated arc-oxygen underwater cutting torch with short length of cable attached.
2. A supply of oxygen gas in cylinders mainfolded together.
3. A suitable oxygen regulator.
4. A standard d.-c. electric welding machine (a.-c. may also be used), 300 amp. capacity for tubular steel electrodes (somewhat higher for ceramic electrodes), 600–1000 amp. capacity for cored carbon electrodes.
5. Standard welding cable of suitable size for the required length connected and properly insulated to the lead cable of the torch.
6. A standard welding cable with clamp for ground connection.
7. Oxygen hose-$^1/_4$" extra heavy-of required length with standard connections.
8. A shut-off switch.
9. A welding lens four to six shades lower than required on the surface (depending upon the visibility under water), properly mounted in a hinged frame attached on the outside of the diver's helmet.
10. A pair of rubber gloves or mittens attached to the diver's dress.
11. A supply of coated electrodes thoroughly waterproofed and fully insulated over the entire length projecting out of the torch.

Safety Precautions

Follow precautions recommended for oxygas underwater cutting, Section 1A above, with the following amendments and additions:

1. The cable and torch insulation and all joints in the circuit should be carefully checked for current leakage at frequent intervals.

2. The diver should not permit any part of his body or gear to become a part of the electric circuit.

3. While a.-c. current may be used, if the diver's body or gear inadvertently "enters the circuit" the resulting "shock" is more pronounced than with d.-c. current.

4. The diver should inspect his helmet and other metallic parts of his gear regularly for deterioration resulting from electrolysis and place his ground connection at points with reference to his position while cutting that will reduce this to a minimum.

5. Always wear diver's rubber gloves or mittens, telephone the surface to shut off current before changing electrodes, and keep it shut off except when actually cutting. Be sure you close the hinged frame holding the welding lens on the outside of the helmet before striking the arc, and remove the electrode before taking the torch under water or returning it to the surface.

6. When using carbon or ceramic electrodes special care must be taken to prevent breakage in handling and while cutting as both electrodes are brittle.

7. Qualified divers who are acceptable electric welders on the surface may learn to operate the arc-oxygen underwater cutting torch with fair results after practicing for a day or two. More recently a number of divers have been able to start cutting underwater after practicing on the surface for a period less than an hour.

Underwater Electric Welding

With a proved electrode specially engineered for the purpose, properly coated and fully waterproofed, such as are now available commercially, it is possible to make welds under water on mild steel with practically the same form and generally the same properties as on the surface.

But such results can be obtained only by skilled operators after adequate train-

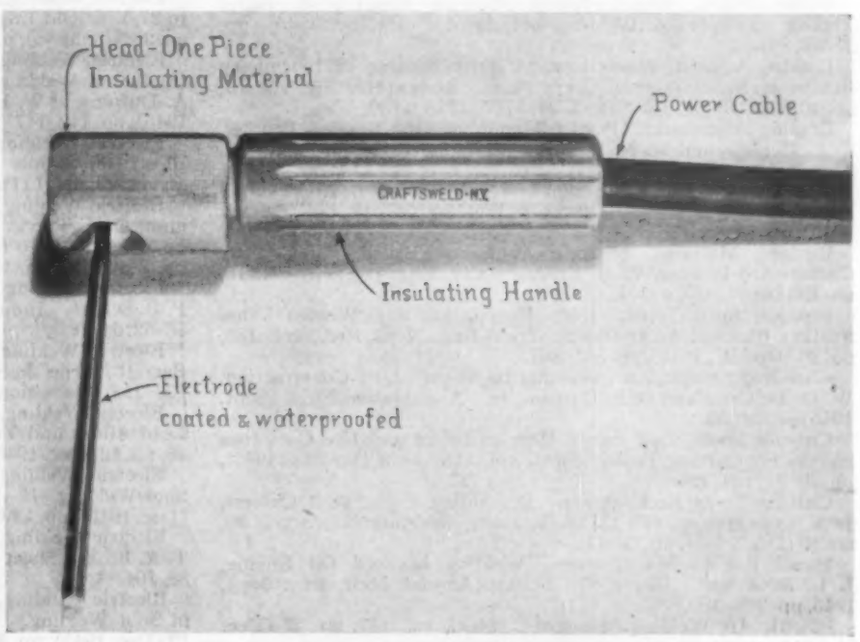

Fig. 3—Underwater Welding Torch (U. S. Navy Model)

ing, and because of the usual handicaps connected with all operations under water, the work requires more time and greater care and skill than on the surface.

Underwater welding on mild steel, when properly done, will develop 80% of the tensile strength and 50% of ductility as compared to the same welds on the surface. Fillet welds are most suitable as they provide a natural groove for guiding the electrode.

The equipment used is identical with that used for cutting except that a fully insulated underwater electrode holder and suitable welding electrodes are substituted for the cutting torch and the cutting electrodes. The safety precautions are also identical. See Fig. 3.

The *actual operation* of underwater equipment is a relatively simple matter in the hands of an expert diver skilled in its use. It will cut steel at any depth with ease.

Its speed is limited only in the same sense as any other mechanical operation that is carried on under water because of the handicaps of the diver's cumbersome dress and weight, the difficult position he may be forced into when attacking the work, the limited visibility prevailing under water, the effect of current or tide, the usual low temperature of the water and the effect of depth.

The diver's progress is also dependent upon the efficiency of the surface equipment, facilities and personnel serving him.

Common Applications

Underwater Cutting

Structural

Cutting of steel sheet piles below water level in cofferdams and bulkheads.

Cutting underwater inlets and outlets in steel bulkheads and cofferdams.

Cutting H-beams and pipe piles to desired levels in underwater foundations.

Pipe Lines

Cutting branch openings or clean out holes in submerged pipe lines.

Removing defective sections of submerged pipe lines.

Miscellaneous

Underwater cutting of metals incidental to marine construction, alterations and repairs.

Salvage

Removing obstructions.

Cutting access holes into sunken vessels for entry of diver and removal of cargo and equipment.

Cutting anchor bolts for removal of equipment attached to sunken vessels.

Cutting of sunken bridges, vessels, etc., into sections small enough for removal with available derricks.

Removal of submerged steel cable, chains, etc., entangled with propellers or rudders.

Underwater Welding

Patching steel cofferdams, bulkheads and vessels below water line.

Attaching brackets to submerged structures for alterations and repairs.

Attaching pad eyes and lifting loops to submerged equipment for raising to the surface.

Attaching guards around propellers without putting vessel in dry dock.

Alterations and repairs to structural elements of hydroelectric, canal lock and other underwater installations.

Sealing leaky rivets below water line.

Arc-Oxygen Cutting Above Water

Cutting Stainless Steel, Cast Iron, Monel, Bronze and other Non-ferrous Metals.

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(*Continued on page 222*)

Special Oxyacetylene Machine Cutting Applications*

By R. F. Helmkamp†

Introduction

LONG regarded as an unfaltering, versatile aid in production lines, the oxyacetylene cutting process continues to amaze us with an endless offering of new developments. Its scope of applications is constantly being broadened, a natural result of its extensive use in the past, and of the government fostered incentive arrangements in so many plants during the war, when the need for new developments was great. Operators of cutting equipment came to the fore with many valuable suggestions, more mechanical minds became better acquainted with the possibilities of the process each day; it is not surprising that the progressive experience and knowledge thus gained enables oxyacetylene cutting methods to keep abreast of the more specialized demands of industry today.

Industry is asking, among other things, for increased accuracy and speed, with more fully automatic operation in oxyacetylene cutting, for production plans for including work more intricate and complicated than ever before. The gas cutting process meets such demands with new applications, and the quick adoption of these various adaptations by industry throughout the country permits the process to compete economically. With widespread usage, with increase in volume of gas consumed, the cost factor decreases.

Today we find fabricators cutting holes to size for tapping without reaming; we find steel mills installing specially designed hot cutoff machines to operate on the transfer tables for use on billets and rolled shapes, hot piercing of tube stock, and various materials slit to specific width. Many mills are now mining spills, skulls and buttons and cutting them to charging box size. In short, the headaches of the past have become profitable business.

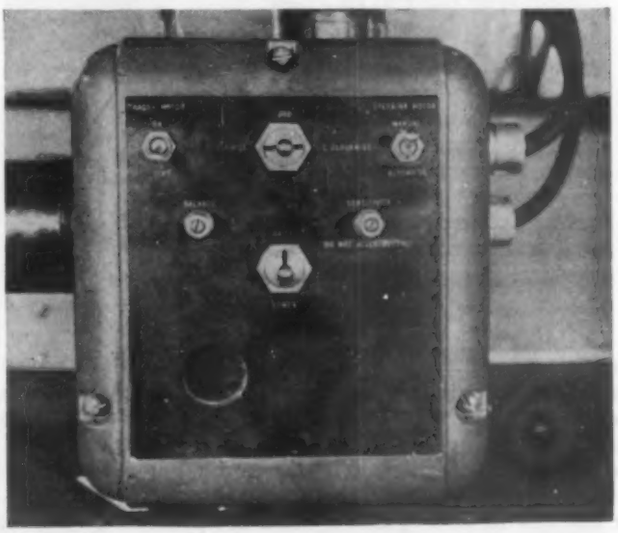
More than a few of these recent achievements are regarded as notable additions to the pages of industrial progress. The natural obstacles to the successful cutting of stainless steel have been overcome, and it is being cut. The electronic tracing device, as a contour tracing and guiding medium for shape cutting machines, is now a reality, it's here, ready to be employed. Machine cutting of scrap, the removal of cobbles from mills, "slicing up" furnace spills with the oxyacetylene process, hot cutting as part of the rolling operation, are all in use, highly regarded as economical and time-saving applications.

Machines that will cut in vertical and overhead planes are beginning to attract attention, and from all indications will lead into some important and complicated operations. The trend toward such thinking has been greatly accelerated by the impact of the past emergency.

The Electronic Tracer

Figure 1, one of the newcomers, and one of the more advanced results of wartime thinking, is the electronic

Fig. 1—Tracing Head of Electronic Tracing Device



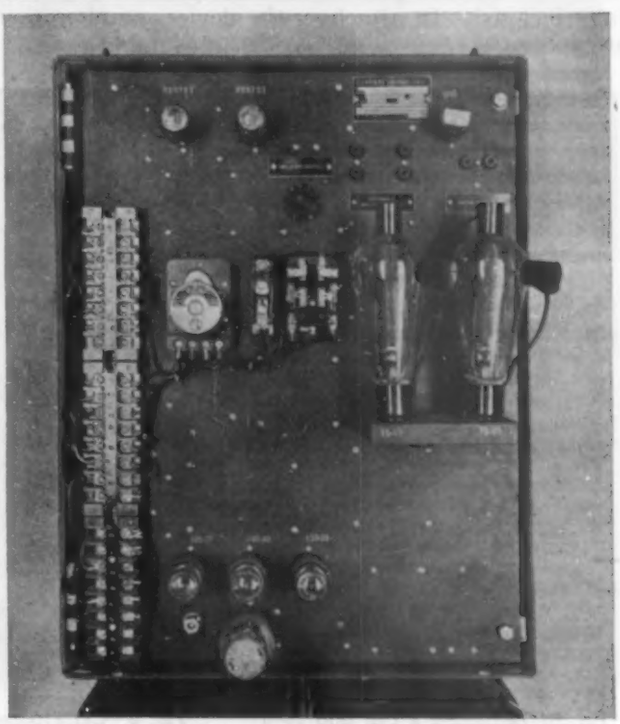
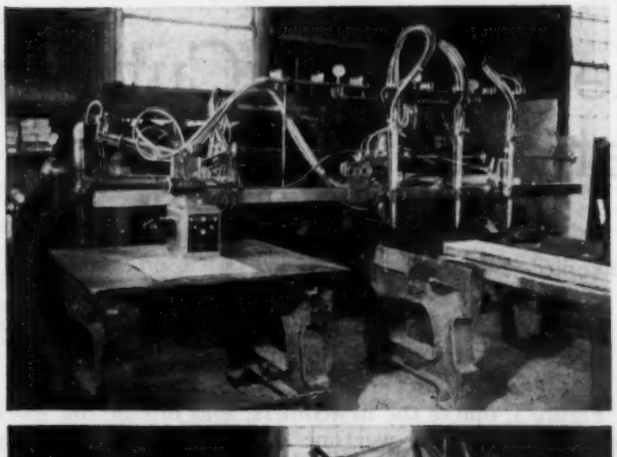


Fig. 2—View of Interior of Tracing Device Control Box

* Scheduled for Twenty-Sixth Annual Meeting, A.W.S., October 1945.
† Technical Sales Div., Air Reduction Sales Co., New York, N. Y.

Fig. 3—Tracing Device Mounted on Stationary Type Cutting Machine



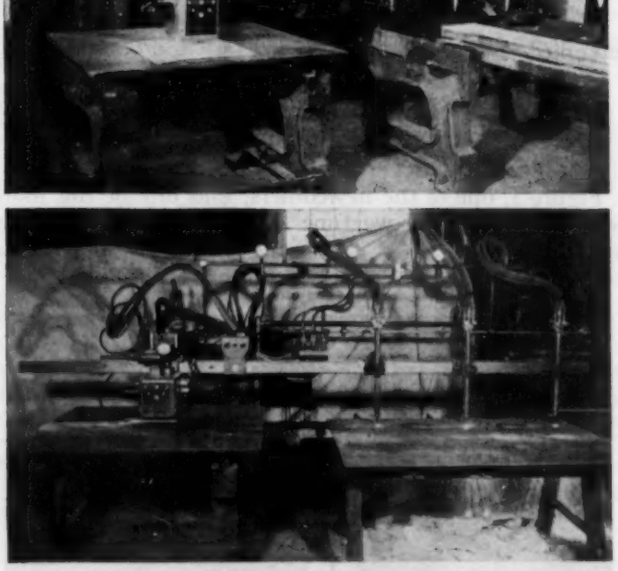


Fig. 4—Electronic Tracer Following Outlines of Wrench Drawing

tracing device. Easily attached to any standard pantograph type cutting machine in place of conventional equipment, the tracer consists of two units, the tracing head and the control box. The tracing head, a self-contained unit attaches to the torch bar of a cutting machine. All parts of this unit, motors, switches, electronic circuit and optical system are protected by being fully inclosed. In attaching the device, no alterations are necessary.

Figure 2 shows the interior of the control box with electronic tubes and circuit arrangement. This unit secures to the machine base. Torch control is completely electric, utilizing the familiar photoelectric cell.

In Fig. 3 we see the tracing device mounted on a cutting machine, with the tracing head poised over a drawing, which is all the templet required. The operation is controlled by light emitted from the base of the head which is projected on the drawing in the form of a spot through the optical unit. This light is slightly deflected by a prism in the bottom of the unit. The drawing or silhouette need only be a black outline about $^1/_8$ in. wide, against a white background, or a white line against black, or any other color combination which provides sufficient light contrast. The process, briefly is this: the light reflected back from the drawing is picked up by phototubes and produces an electric signal, the strength of which depends upon the intensity of the reflected light. The signal is amplified to provide the current which flows through the steering motor and causes its rotation. The light seeks constantly to position itself half on the white portion and half on the black portion of the drawing.

Figure 4 shows the tracing head following the white outlines of a wrench upon a black background, guiding the torches, which cut wrenches from the steel with great accuracy. When the light falls entirely upon the black much of it is absorbed, producing a weak signal which causes the spindle to move toward the white. If the light produces a strong signal by falling entirely upon the white the tracer restores equilibrium by moving toward the black. Human error and normal mechanical restrictions are eliminated. Alterations in this type of templet can be quickly made, and the storage of hundreds of drawings constitutes no problem, as compared to metal patterns.

Stainless Steel Cutting

The question that seems to arise most frequently with the introduction of a new steel is: "Can it be cut and can we weld it?" Stainless steel cutting is a development born of necessity and demand, for the very elements which produce its desirable corrosion-resistant properties

Fig. 5—Beginning a Cut Into 18-8 Stainless Steel, of $2^3/_4$ In. Thickness

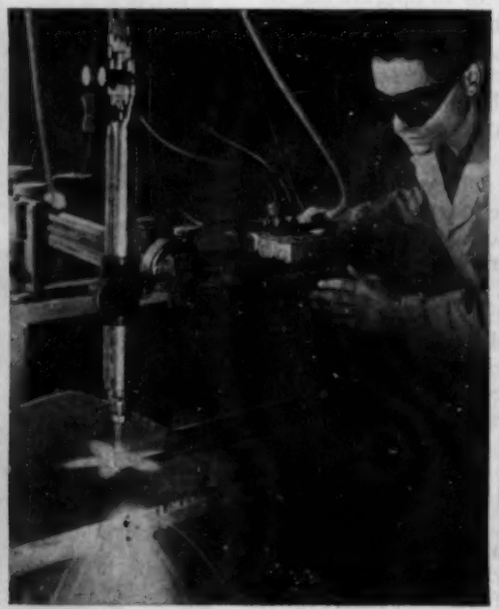


Fig. 6—Cut Progressing Into Stainless, Employing Flux-Injection System

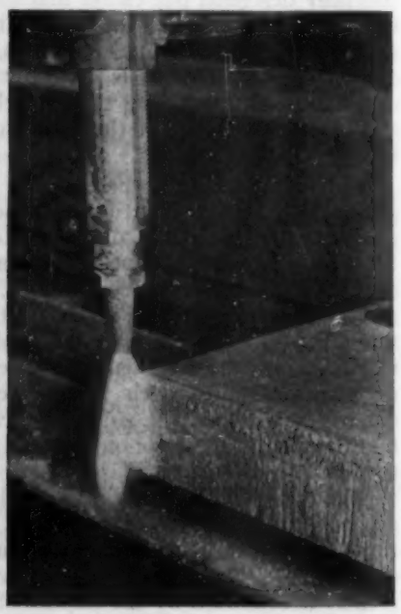


Fig. 7—View of Completed Cut Through Stainless Steel

also produce oxides which heretofore have reduced gas cutting to a slow melting-down procedure. The problem has been overcome by the Flux-Injection method.

Figure 5 shows the beginning of a cut into 18–8 stainless of $2^{3}/_{4}$ in. thickness, employing this new development. The Flux-Injection method may be used with standard cutting machines equipped with a modified machine cutting torch and standard tips. For hand cutting a suitably adapted torch is also available.

The cut is progressing through the stainless steel, the torch cutting a clean sharp kerf (Fig. 6). The process consists of progressively heating the alloy and injecting a suitable noncombustible flux into the heated zone and into the kerf of the cut. The flux lowers the melting temperature of the oxide, producing a more fluid slag stream, which permits severing by the oxyacetylene process in other than a melting fashion.

Figure 7 is a view of the completed cut which speaks for itself as to quality and the proficiency of this application. Mills, foundries, scrap dealers, warehouses and fabricators will welcome this new process.

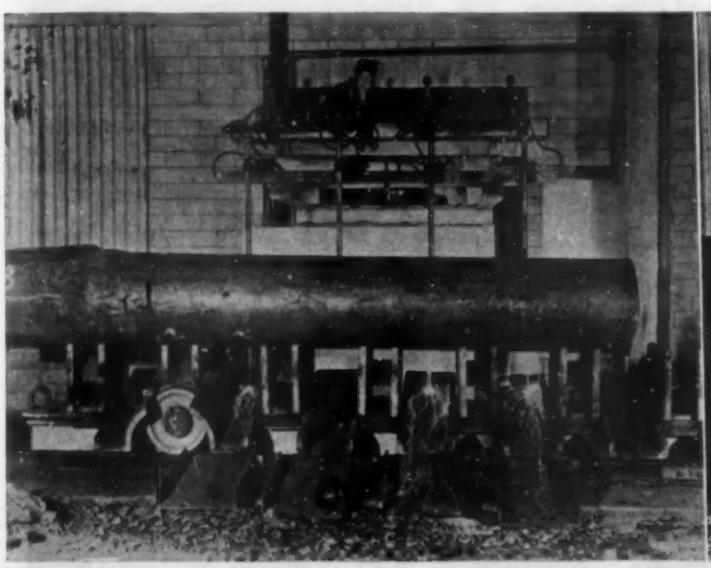
Hot Cutoff Machines

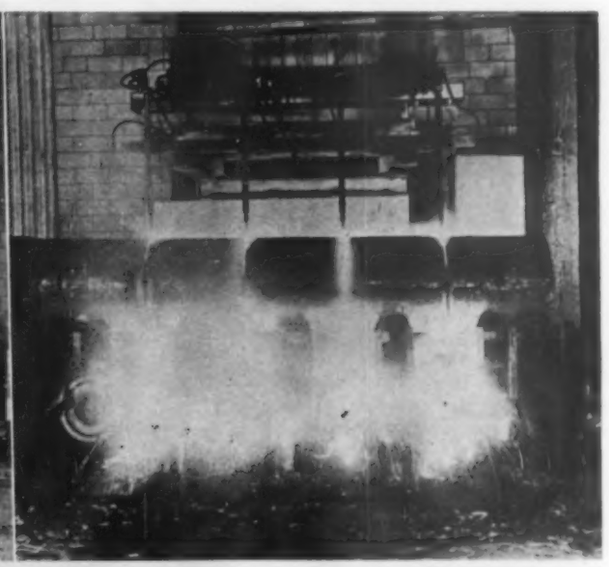
Hot cutoff machines are rapidly gaining a well-deserved popularity on production of forging slugs, cropping operations, cutting operations, cutting specimens, cutting multiple lengths and severing on multiple and continuous forging operations. From a mill standpoint one outstanding advantage of cutting at highly elevated temperatures is that more continuous operation may be realized. From a metallurgical point of view there are many advantages. Aside from the fact that high-temperature cutting is many times faster and cheaper than cutting at room temperatures, alloy steel, and any large mass of steel, requires preheat for dependable results, and hot cutting in the proper sequence of operations is the logical method.

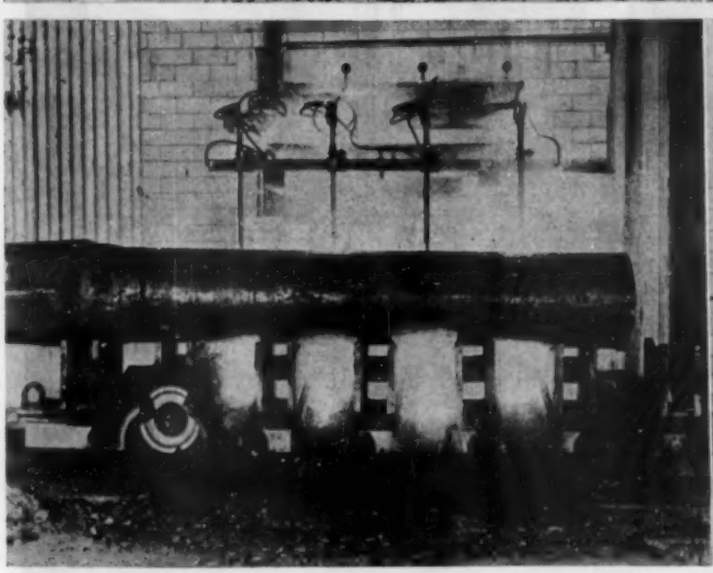
Figure 8 shows a multiple torch round stock cutting machine, beginning four simultaneous cuts in a hot-forged alloy round. The torches are particularly suited to this type of work, being of heavy duty, water-cooled construction and are quite capable of withstanding the great heat such work necessarily engenders.

Fig. 8—A Multiple Torch Round Stock Cutting Machine, Starting Four Cuts

Fig. 9—Cuts Progressing Through 28-In. Diameter Round







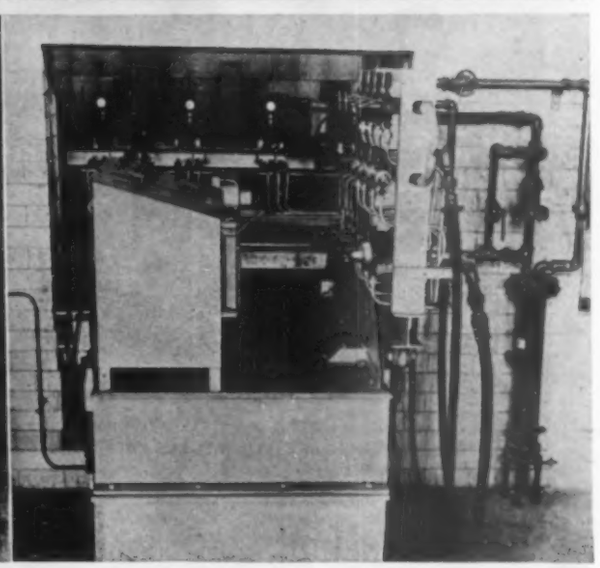


Fig. 10—Cuts Nearly Finished. Severed Sections Will Remain in Position

Fig. 11—View of Individual Torch Valve Switch Controls

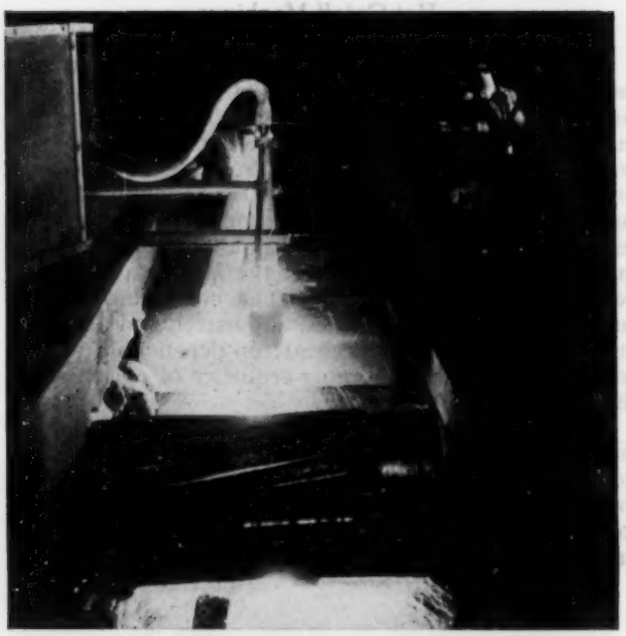


Fig. 12—A Special Billet Cutting Machine in Operation

In Fig. 9 the cuts are progressing, with the four valveless torches well into the 28-in. diameter preheated alloy round. The piece is positioned on vee blocks, on a special car, which has been locked in place on the rails in order to serve as a cutting support for the large forging.

Figure 10 shows the four cuts nearly finished. When completely severed, the separate pieces will remain positioned on the vee block supports. Such an operation effectually demonstrates the power of the flame, and points the way to new ideas.

The control pulpit of this multiple round cutting machine is interesting in itself (Fig. 11). The individual torch valve switch controls and the master switch controls are at the left. Individual regulators are piped through solenoid control valves, which serve each torch independently and selectively. The operating pulpit is on the opposite side of the wall from the actual cutting operation.

Figure 12 is a billet cutting machine, in operation in a mill which had a large order for 6- x 6-in. billets for shell stock. The problem was one of cutting the billets to specific lengths on the roll line. The problem then resolved itself into one of cutting, keeping up with mill production. The oxyacetylene process provided the

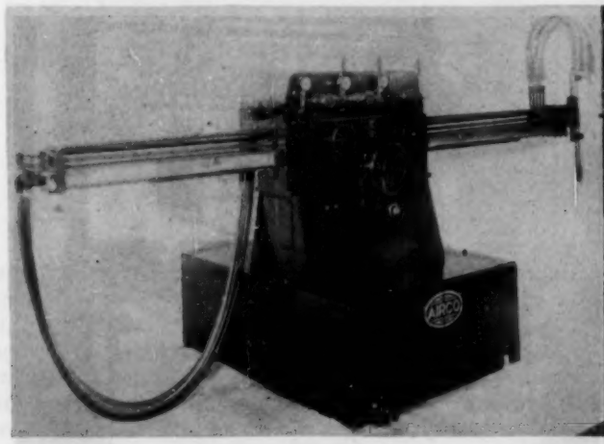


Fig. 13—Specially Designed Bloom Cutting Machine

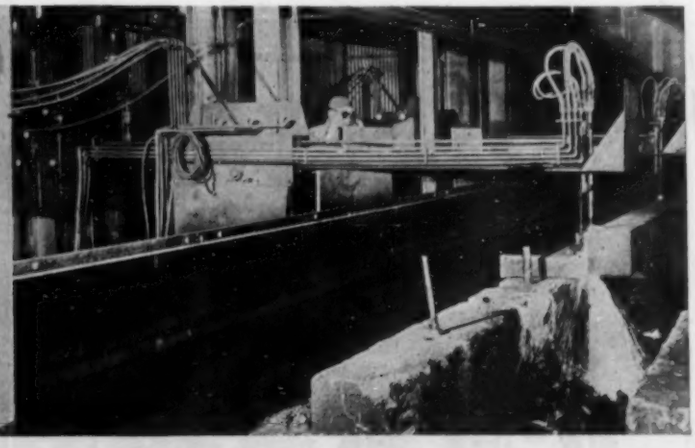


Fig. 14—Bloom Cutting Machine in Action

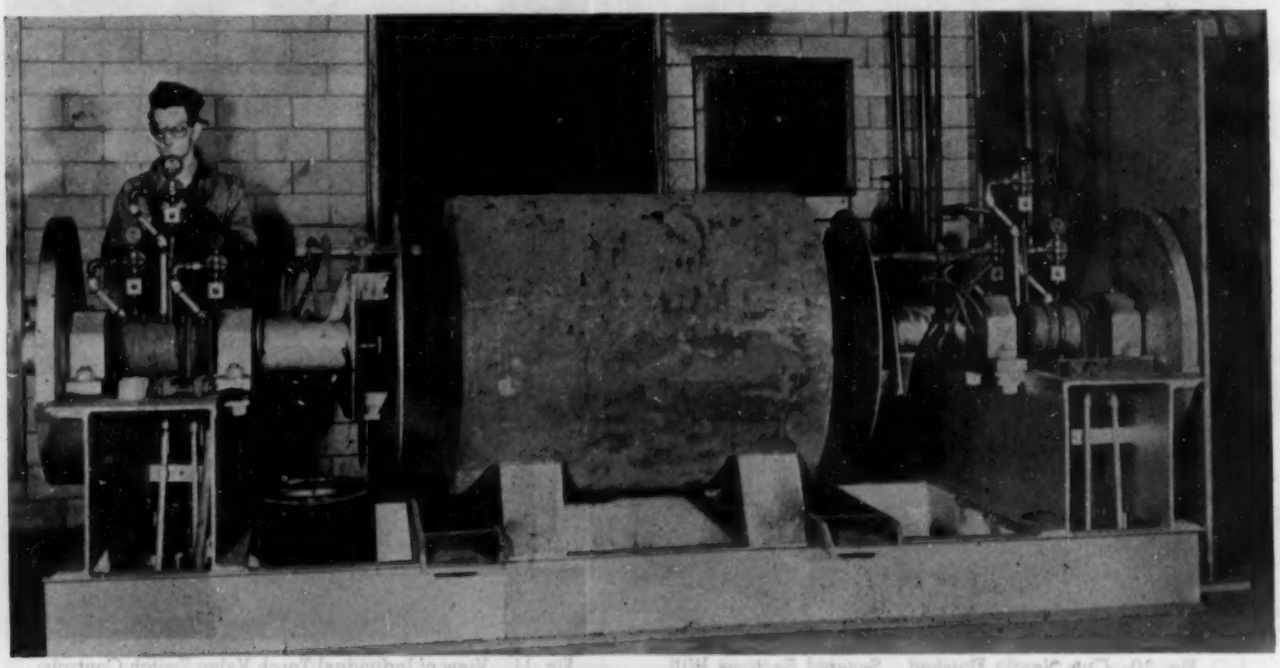


Fig. 15—Circle Cutting Machine Operating in Vertical Plane

Fig. 16—Portable Cutting Machine Cutting and Beveling in Horizontal Plane

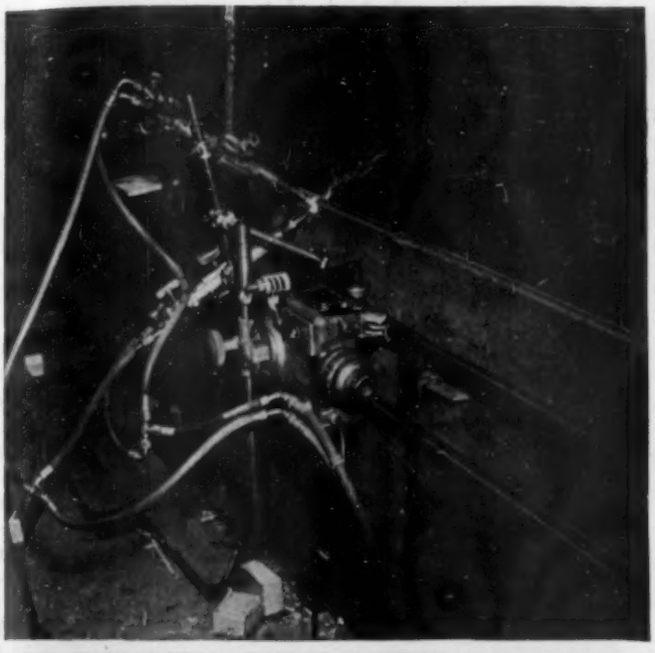


Fig. 17—Same Machine Cutting Vertically on Upright Plate

Fig. 18—Portable Cutting Machine Cutting Oval Holes, Guided by Roller Attachment on Templet

Fig. 19—Finished Oval Holes, Cut Cleanly with Dimensional Accuracy

answer with two standard straight-line cutting machines. Cutting the billets at rolling temperatures of from 1700 to 1800° F., these two units easily keep pace with the rolling mill cycle of one billet per minute. The actual cutting time is from 15 to 18 sec. per cut.

Each machine is equipped with a water-cooled torch. A special arm extending before the machine through a screen for a distance of 4 ft. supports the torch. The screen protects both operator and machine from the heat. Billets are cut side by side on the transfer table to reduce the time required for positioning. The torch is set at a slight angle leading back from the line of the cut to obtain faster starts and insure complete severance. This has been an extremely satisfying application in the production of thousands of tons of shell stock.

Performing a specific cutting operation on alloy steel blooms at elevated temperatures is a similarly profitable utilization of the cutting flame (Fig. 13). This special bloom cutting machine, was designed for a plant which was confronted by the task of cropping blooms measuring from 10 to 18 in. square and from 8 to 27 ft. in length.

Figure 14 shows this machine in operation, on a 15-in. square hot-alloy bloom, which must be cut at high temperature to avoid checking and cracking, because of its chemical analysis. Both bar and torch are water cooled, and the various vertical, horizontal and angular adjustments possible with this torch setup facilitate the cutting of off-size and deformed shape of blooms. On hot-alloy steel the cutting speed is 5 in. per minute. Using a suitable tip size the oxygen cutting pressure here is 38 psi. With such equipment the plant has no difficulty in supplying the forging field with square cut material of any

length and weight. They are also able to retain the crop ends at the mill.

Special Cutting Adaptations

One of the major departures in flame cutting is that called "multiplane cutting." While not a radical departure, it brings the process to a new threshold of applications of usefulness, causing a definite change in attitude toward the function and field of flame cutting. Heretofore, most machine gas cutting has been done on one plane, with the work in a flat position. With advancement in welded fabrication are coming requirements for more advanced multiplane cutting. Industry is expressing its desire for intricate adaptations that parallel machine tool operations.

Figure 15 is an example of cutting in a vertical plane, with the torch adjusting itself to the fashion of the piece, instead of the piece being positioned flat to suit the torch. This specially designed circle cutting machine is operating in a vertical plane on each end of an extruded hot-alloy forging. With the material stationary, supported on vee blocks, the torches advance from the outer edges of the forging to the gage point, then revolve and trim the heavy extruded piece to a definite length. Both ends are cut simultaneously.

Figure 16 is a demonstration of cutting in a horizontal plane. Here a light portable machine is bevelling a vertically positioned ship's plate, moving along a track which is literally "standing on edge." A set of confining wheels, riding beneath the track, hold the machine in position with the aid of a spring-loaded frame attached to it. This setup enables machine cutting in horizontal, vertical or even overhead positions.

In Fig. 17 we see the same machine cutting vertically, climbing straight up a perfectly upright plate. Again the machine holds its position by the spring-loaded frame whose wheels follow the underside of the track, but in this instance the drive wheels are geared, to obtain traction on the racked rails. Such adaptations are used chiefly in the shipyards at present.

Still another function of this versatile cutting machine is seen in the cutting of oval holes (Fig. 18). Precision cutting is attained through the use of a templet which guides the machine by means of roller attachments. The templet holds its position by its own weight, with the additional aid of rubber pads on the underside.

Figure 19 shows the flawless appearance of these holes after cutting. The rather novel method of guiding employed enables the machine to cut such apertures with no dimensional variation, in a precise, rapid and economical operation.

Still another way of increasing production is to add

Fig. 20—Twenty-Torch Setup on a Standard Stationary Type Cutting Machine

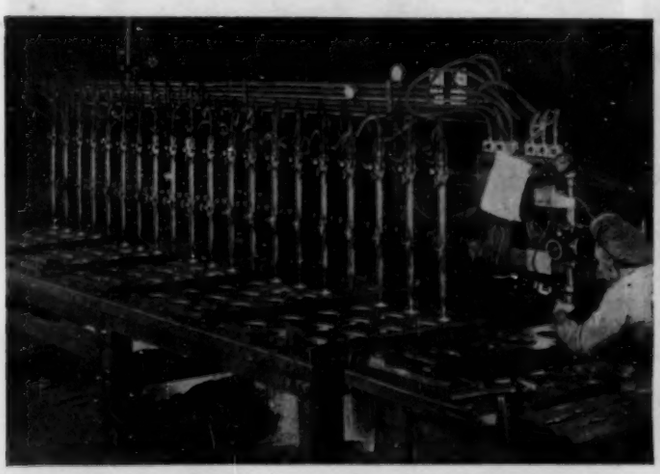


Fig. 21—Six-Torch Line Type Billet Nicking Machine in Operation

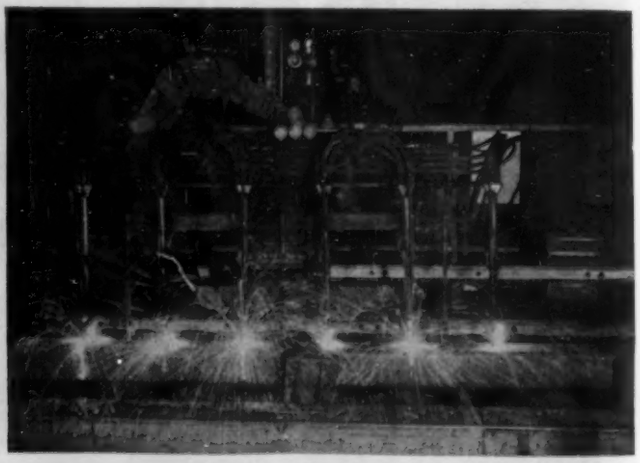


Fig. 22—View of Mechanical Arrangement of Billet Nicking Machine

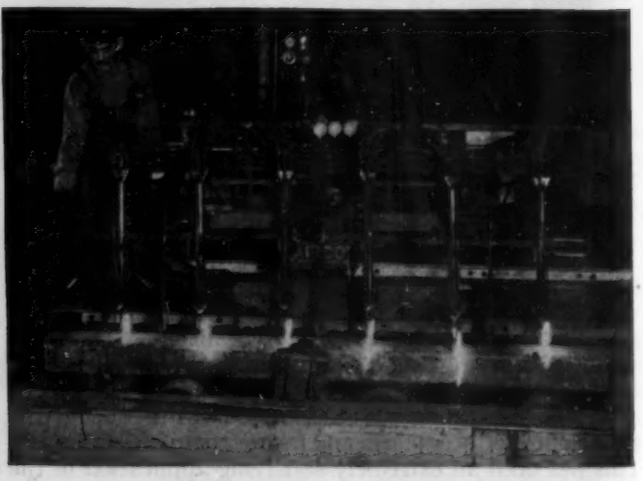
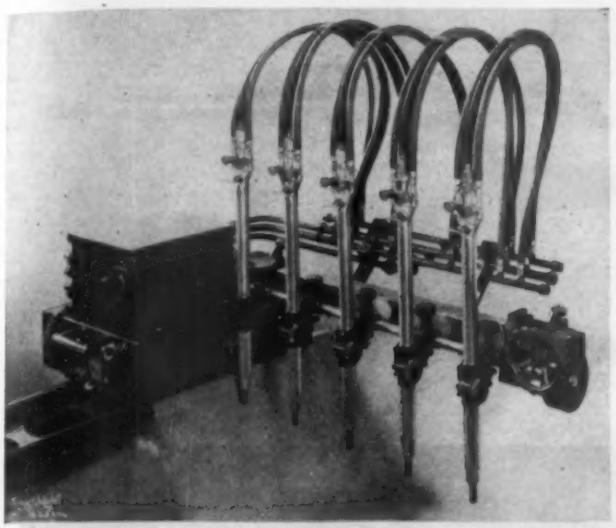
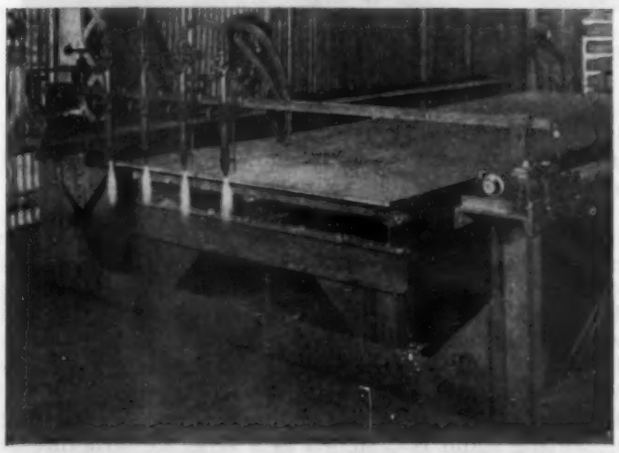


Fig. 23—Billet Being Positioned Beneath Torches of Billet Nicking Machine

Fig. 24—Slab Slitting Machine, Showing Detail of 5-Torch Setup





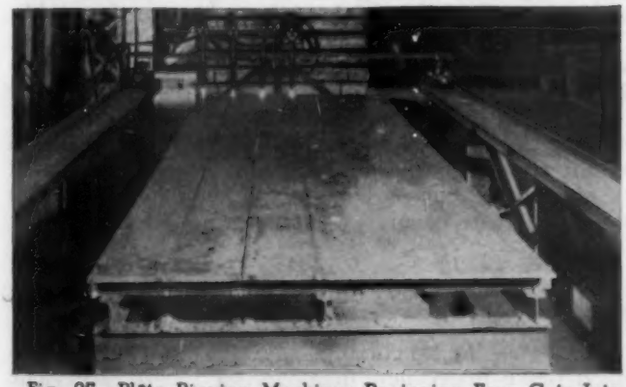


Fig. 25—Plate Ripping Machines Beginning Four Cuts Into Plate (Center)

Fig. 26—Cuts Ending, Plate Divided Into Four Sections by Flame

more torches and work them simultaneously. In Fig. 20 we see what is considered a record number of torches mounted on a machine, 20 torches on the bar of a stationary type, pantograph cutting machine. Circular openings are being cut in plates held in position by strongbacks, that assist in controlling plate motion and insure accurate cutting, with the pattern being guided by templets. This is an unusual setup and while the machine was not designed for so many torches the operation was a successful one foreshadowing coming events. Fifteen years ago, four-torch or any multiple-torch setups were a novelty.

Billet Nicking

Figure 21 is a billet nicking machine in action. During World War I it became necessary to develop a method for producing projectile stock blanks in quantity which would be both speedy and economical. Manufacturers turned to oxyacetylene, introducing a process of nicking billets by flame prior to the application of pressure or shock by drop hammers, bulldozers, hydraulic presses, or by dropping the nicked billets from a height onto an anvil. Billet nicking is possible as a practical process through a definite metallurgical fact: that when flame is applied to metal the metal expands. The high local temperature coupled with the quenching effect of the cold mass of adjacent metal causes a state of high stress in adjoining areas. Shock or pressure, when the metal's elastic limit has been reached, permits ready breaking of the piece into prescribed lengths.

In Fig. 22 we see the mechanical arrangement of this machine, used in nicking blanks for 105-mm. shells. A six-torch, line type machine, it represents a marked advance in the oxyacetylene process of billet nicking, being one of the machines employed in World War II, by manufacturers with large contracts for shells, which produced the clean, shear breaks required under inspection procedures. A standard straight-line cutting machine propels the six torches across the width of the billet, the machine moving on a track which is itself mounted upon rollers at each end, with a sprocket arrangement and hand control which permits adjustments sideways. The machine and its track may be moved bodily in either direction toward the ends of the billet. A bar mounted on top of the machine supports the gas manifold, the six torches and a floating device which adjusts itself to the surface contours of the billet, assuring accurate positioning of each flame. In this figure, the operator holds the control valve which delivers the gases into the manifolds.

Figure 23 shows the billet rolled into correct position beneath the torches. The simple hand pointer serves as a stop gage, being set the same distance from the end torch as the torches are spaced from each other; with the pointer resting against the end of the billet, therefore, the flames are positioned correctly for nicking lengths.

Nicking and breaking billets in this fashion serves two purposes, it cuts billets into shell stock lengths for manu-

Fig. 27—View of Portable Hook-up from Trailer Through Regulator to Manifold

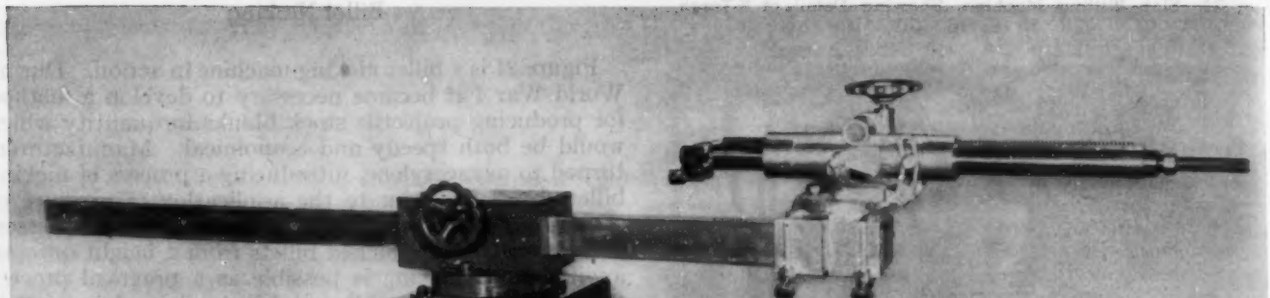


Fig. 28—Torch Positioned Horizontally in Holder. Three-Direction Adjustments Possible

facture and it produces fractures which will disclose the presence of seams, pipes, segregations, etc.

Slab Slitting and Plate Ripping

Another application stemming directly from wartime ingenuity is that of ripping slabs and plates by flame. During the crisis it became very difficult for rolling mills to procure adequate equipment. Such production bottlenecks led directly to employment of the flame. Oxyacetylene cutting aided materially in speeding plate and slab deliveries then, and steps naturally into a niche in today's industrial problems. Many mills now possess complete cutting machine tables and roller lines made up to accommodate straight-line cutting equipment.

Figure 24 shows a machine designed for slitting slabs into billets. The machine, equipped with standard cutting torches, moves on its track the length of a slab and divides it into as many billets as there are torches mounted. The machine is counterbalanced so that the torches may be placed anywhere on the supporting arm. Adjustments are provided so that the torches can be tilted in either direction, leading or lagging while the cut is in progress. Torches may also be adjusted vertically. Solenoid control valves regulate the preheat gases and the cutting oxygen. These valves are controlled by a single 3-position switch which permits progressive cutting on and off of each line feeding gas into the three pipes leading to the machine's manifold.

The necessity for buying and storing large quantities of various width plates is eliminated by the plate ripping machine (Fig. 25). Wide plates may be purchased and divided into as many narrower strips as desired, and of any selected widths, with allowance made for kerf widths.

This unit consists of two small portable machines running on parallel tracks that span the work area. The machines are connected by a torch mounting bar. An ingenious equalizing link motion increases or decreases the speed of the machine to the left which is equipped with all controls. Should one machine run faster or slower the equalizing arrangement immediately corrects the error. Because accuracy of cut depends upon the stability and straightness of the machine tracks their supporting stand is designed as a separate structure to avoid the conduction of heat from the cutting table. The two units have no contact with each other. Space is provided for the operator to move alongside the machine.

In Fig. 26 the cuts are nearly completed. The trimming of the plate edge by the first torch is done for a definite reason. Equal heat distribution on each side of the strip being cut prevents warping or bowing which would otherwise occur.

Heavy Scrap Cutting

The phrase "scrap cutting" covers a multitude of jobs which make many new demands on the oxyacetylene process especially in the mills, railroad shops and wherever else it is desirable to economize by retrieving materials formerly too bulky to handle or too low in value. With the cost of the process declining, such diversified tasks as cutting up massive spills, dismantling heavy

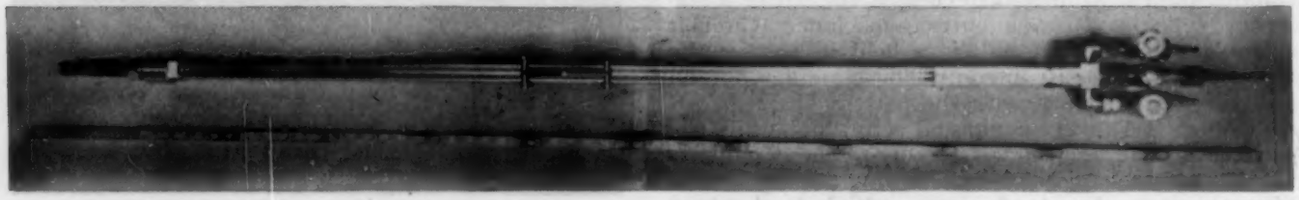


Fig. 29—A 6-Ft. Hand Cutting Torch for Heavy Duty Cutting

steel equipment and reducing large pieces of metal to charging box size many mills are now mining the buttons and skulls buried years ago. Cutting techniques have been developed for such tasks with equipment following suit. For instance, the increasingly large volume of oxygen used at widely separated locations in plants has focused attention on the problem of handling large quantities of oxygen in cylinders. The natural result is the trailer system, or bulk distribution by specially designed truck and trailer, a method of many advantages. By employing the trailers, with a control house, at the trailer park, we eliminate cylinder handling. The advantages of the trailer are enhanced by the use of a portable heavy duty regulator on wheels. This unit controls the flow of oxygen from the storage trailer which may be readily positioned and quickly moved. The 10,000 cu. ft. capacity regulator in the center of the unit may be set to deliver into the manifold any desired operating pressure. It is equipped with two safety devices. The valve at the outlet end of the unit enables the whole system to be readily cut off, moved, and cut in again, without adjusting the regulator. The portable manifold receives the controlled flow of oxygen from the flowmaster and distributes it to the operating hose lines. This unit is also easily transported, and may be placed at a distance from the trailer supply.

In Fig. 27 we see how such a unit is connected, the regulator ready to receive the oxygen from the outlet of a large capacity trailer; step it down from trailer pressure, and convey it to the manifold for individual hose line distribution.

Torches and other equipment have been developed to meet modern requirements (Fig. 28). Here we have a heavy duty torch with a 2-in. diameter barrel. This is a valveless, water-cooled, rack type machine cutting torch. It is standard equipment and can accommodate $^3/_4$-in. hose to feed the large tips which go up to number 18. The heavy duty machine cutting torch is mounted on a heavy duty straight-line cutting machine by means of a torch holder, racked bar and geared slide box which were designed for this torch. The 6-ft. bar racks horizontally through the slide box and may be extended to its full length on either side of the machine. The swivel slide box mounting provides for rotation of 360° and locking in any position. The torch holder mounts in any one of four positions on the square bar and is readily moved and locked in position. Self locking vertical adjustment of the torch is by means of a hand wheel. The torch may be swung through 360° in one direction and 15° either side of the vertical in the other direction. Bar and torch are water cooled by the same system. The water circulates through the torch first, then moves into one end of the bar and out the opposite end. Baffles in the end of the bar insure correct water volume for complete protection.

Another heavy duty cutting tool is a rugged hand cutting torch, a 6-ft. piece of apparatus which allows the operator to stand clear of the heat of the work (Fig. 29). This torch is designed for rapid economical cutting through heavy thicknesses of metal. It has demonstrated its value in various mills, foundries, scrapping operations and forge shops.

Oxygen Lance

To the problem of cutting extremely heavy thicknesses of steel which are beyond the limit of any torch, the oxygen lance provides a ready answer. Such work may be handled by the lance alone or by means of the lance inserted into a cut opened by a cutting torch. The lance ordinarily consists of a length of black iron pipe fitted with a valve at one end through which oxygen is supplied. The procedure is a simple one; the steel is brought to a bright red heat, the end of the lance is brought into contact with it and the oxygen valve is opened. The lance pipe directs oxygen to the preheated part of the work, the oxidation of the steel and the propagation of the cut are continued by the heat liberated through the steady combustion of the parent metal and the oxygen.

Figure 30 is an open-hearth spill, measuring 10 x 5 x 15 ft., being sliced by the lance into proper size for re-

Fig. 30—10- x 5- x 15-Ft. Open Hearth Spill Being Spliced to Charging Box Size by Lance

Fig. 31—View of Surfaces of Another Spill After Lancing

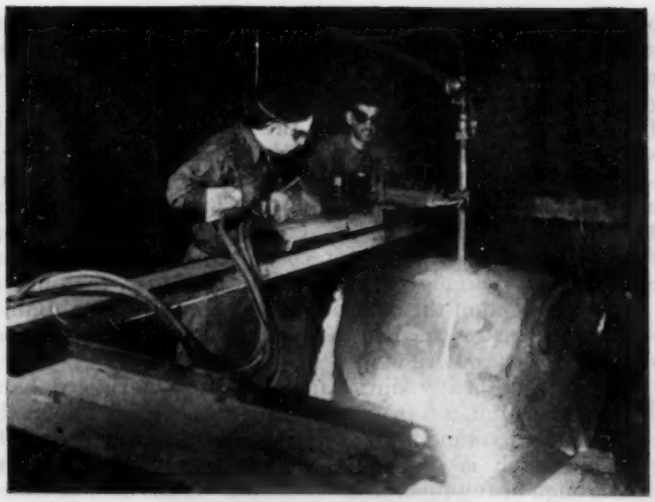


Fig. 32—Portable Cutting Machine with Trailer, Cutting Through 30-In. Diameter Round

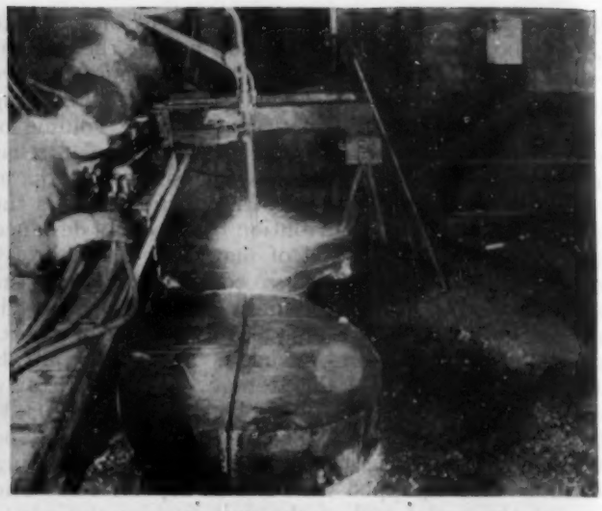


Fig. 33—Same Machine Continuing Scrapping Operation on 30-In. Diameter Hot Top

melting. This piece, weighing approximately 75 tons, was severed in 24 hr., consuming between 20,000 and 25,000 cu. ft. of oxygen. Being a mixture of steel, slag and brick, a flux in the form of old nuts and bolts was fed ahead of the jet to aid in the cutting, in a manner similar in theory to that of a starting rod for hand scarfing torches.

Figure 31 shows the surfaces of another such massive piece after lancing. This spill was subsequently broken up by dynamite inserted into holes which were lanced in the piece. The oxygen lance has also been successful in the cutting of nonmetals such as concrete. The lance consistently makes difficult jobs appear easy.

Another example of heavy scrap cutting is this heap of 30-in. diameter ingot hot tops to be cut to charging box size (Fig. 32). Today it has become a routine job with up-to-date equipment.

Figure 33 is the same machine setup continuing this operation reducing the sections further by cutting them in half. Scrapping of this type is now a standard plant procedure and also a very profitable one.

Conclusion

Postwar production plans must utilize proven wartime developments, for as industrial fields of endeavor grow larger her demands will become more complicated. For accelerated production schedules, the field of possible processes must be scanned and evaluated, on an economic, dependable and time-saving basis. Gas cutting fits such a picture.

It takes vision, backed up by plenty of courage and lots of hard, and sometimes discouraging, work to do something progressive. The easy course, "let's do it as it has been done for years; it works, why change?" does not allow a company or an individual the full advantages of new developments.

Those who have the courage and the will to work out new production schemes, employing gas cutting, will find ready and willing assistance from the gas and apparatus supply companies. Advantages thus gained put such industries in the lead; to be competitive others must follow.

As outlined, industrial growth is based on plenty of courage and a will to work. Progress is made by those who expend effort and thought. The atomic bomb itself was born of the truth that man, like the turtle, makes no progress until he is willing to stick his neck out.

(*Continued from page 212*)

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(*Continued on page 241*)

Some Improvements Resulting from Studies of Welded Ship Failures*

By David B. Bannerman, Jr.,† and Robert Tyrrell Young†

Introduction

SINCE electric welding was first accepted for minor work on ships its use has been gradually extended from the joining of members of secondary importance and the fabrication of such parts as bulkheads, tunnels, deckhouses, etc., to the final application of welding the entire vessel. As a result of this gradual development there are now in existence ships built during the period mentioned which represent all degrees of the application of welding in their construction. For this reason it would be a little difficult to define a welded ship with some riveting as opposed to a riveted ship with some welding. For the purpose of this discussion, however, we shall consider that a ship is welded if all the bulkheads and decks as well as the shell butts are welded, even though the shell seams and side frames be riveted. On the other hand, a ship in which only the bulkheads and the butts of shell and decks are welded, while all shell and deck seams are riveted, would be considered a riveted ship.

The earliest all-welded ships were small and built largely from designs for riveted vessels. Welding was progressively applied to larger vessels and the designs thus evolved have become more suited to welded construction. Previous papers presented before this Society at annual meetings have described in detail the steps in this gradual evolution toward the all-welded vessel.

The all-welded vessel is therefore not a development of the war emergency; in fact, several of the large welded tankers were already in existence before the war, but it had by no means supplanted the riveted ship, except in the smaller vessels up to about 300 ft.in length which were almost entirely of all-welded construction. There were many reasons given for retaining some riveting. Among these were the desire to use existing equipment and personnel trained for riveting; yard layout and available power supply, limited lifting capacities and the facility of erection provided by rivet holes which could be used for bolting up. The cost of the welded ship was not sufficiently lower, if at all, to warrant abandoning the existing facilities for riveting. Even the Liberty ship, which was built in mass production, was not originally designed strictly for welding, and in most yards frames were riveted to the side shell. Such was the picture at the beginning of the war.

Now, however, vessels of nearly every type are being built of all-welded construction. These include barges, tugs, small cargo ships such as the Army 167-ft. supply vessels, cargo ships of the Maritime Commission classes known as N3, C1A, C1B, C2, C3 cargo and C3 passenger-cargo combination, C4, the Liberty ship in some yards small tankers, the standard T2 tankers, and the very large tankers built at the Welding Shipyards, Inc., which are 541 ft. long and of 14,000 gross tons.

At the present time, whenever the welded ship is mentioned, one immediately thinks of the structural failures which have occurred under various conditions and the possible causes of this phenomenon. It is the purpose of this paper to discuss these structural failures in the hope that the presentation of facts in the record of these ships in service related to the whole shipbuilding program may dispel some of the rumors which have multiplied in conseqeuence of the secrecy imposed by war conditions.

When the war created a demand for larger numbers of ships it was necessary to build and equip new yards and train new labor in the shortest time. By adopting welding it was possible to establish a shipyard without large quantities of heavy machinery such as shears, punches and planers. It was also possible to fabricate large subassemblies, wherein an individual workman performed the same operation over and over again. Through the use of these large subassemblies the output from a given plant was increased over the corresponding output of a shipyard building riveted ships plate by plate principally by reason of the shorter time required on the shipways. The difficulties of obtaining essential equipment and especially of training welding operators were formidable, but despite these difficulties the first announced goal of three ships per day, which was considered fantastic by many, was in fact doubled at the peak of production. The record of these quickly built welded ships has more than justified the adoption of welding in view of the number of vessels built, their ability to withstand enemy action without fatal damage, and the comparative ease with which repairs can be made to them. In fact, considering the 3000 or more welded ships built under the most adverse conditions, the loss through structural failure of a half dozen is less to be wondered at than the entirely satisfactory service given by hundreds of them when they were urgently needed.

Section I—History of Failures in Welded Ships

1. *Nature of Failures*

A phenomenon as complex as this one of ship failures is bound to result in a variety of explanations, each with its advocates and opponents. The observations which follow are based entirely upon a study of the actual record of reported failures, and it is not intended that one or another of these explanations will be proved or disproved.

A very complete record has been kept of all failures reported both during construction and after vessels were

* Paper presented before the Society of Naval Architects and Marine Engineers, New York Metropolitan Section, December 6, 1945.

† American Bureau of Shipping.

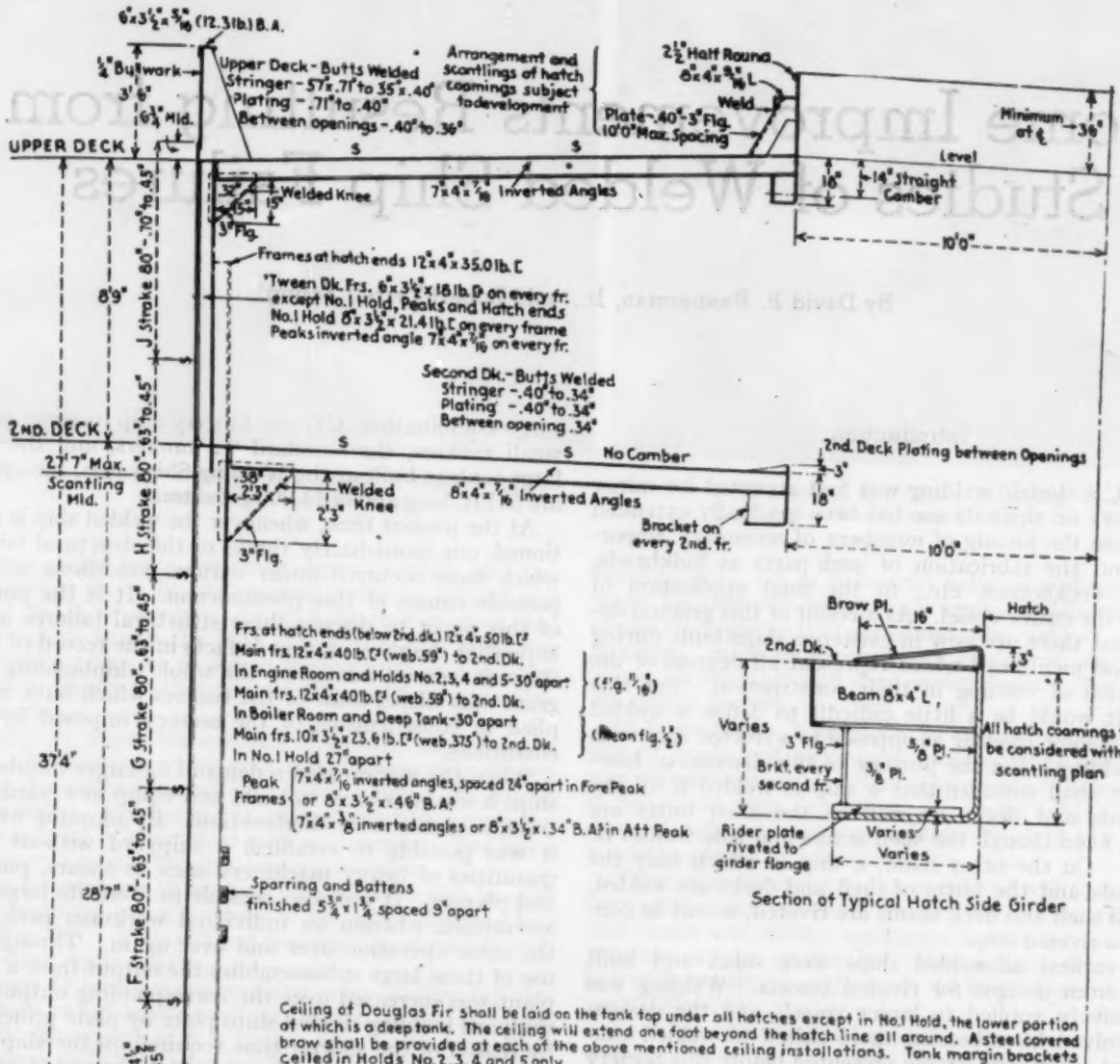

UPPER DECK
2ND. DECK
Upper Deck - Butts Welded
Stringer - 57's .71" to 35's .40"
Plating - .71" to .40"
Between openings - .40" to .36"
Arrangement and scantlings of hatch coamings subject to development
Plate - .40" - 3" Flg. 10'0" Max. Spacing
Minimum at ℄ 36"
Level
14" Straight Camber
10'0"
Welded Knee
7"x4"x 7/16 Inverted Angles
Frames at hatch ends 12"x4"x35.0lb. [
"Tween Dk. Frs. 6"x3½"x 18lb. [on every fr. except No.1 Hold, Peaks and Hatch ends
No.1 Hold 8"x3½"x 21.4lb. [on every frame
Peaks inverted angle 7"x4"x 7/16 on every fr.
Second Dk. - Butts Welded
Stringer - .40" to .34"
Plating - .40" to .34"
Between opening .34"
No Camber
2nd. Deck Plating between Openings
Bracket on every 2nd. fr.
Frs. at hatch ends (below 2nd. dk.) 12"x4"x 50lb. [
Main frs. 12"x4"x 40lb. [(web .59") to 2nd. Dk.
In Engine Room and Holds No. 2, 3, 4 and 5 - 30" apart
Main frs. 12"x4"x 40lb. [(web .59") to 2nd. Dk.
In Boiler Room and Deep Tank - 30" apart
Main frs. 10"x3½"x 23.6lb. [(web .375") to 2nd. Dk.
In No.1 Hold 27" apart
Peak Frames
7"x4"x 7/16 inverted angles, spaced 24" apart in Fore Peak
or 8"x3½"x .46" B.A.
7"x4"x 3/8 inverted angles or 8"x3½"x .34" B.A. in Aft Peak
Sparring and Battens finished 5¾"x1¾" spaced 9" apart
Brow Pl.
Hatch
2nd. Dk.
Beam 8"x4" L
Varies
All hatch coamings to be considered with scantling plan
Brkt. every second fr.
Rider plate riveted to girder flange
Section of Typical Hatch Side Girder
Ceiling of Douglas Fir shall be laid on the tank top under all hatches except in No.1 Hold, the lower portion of which is a deep tank. The ceiling will extend one foot beyond the hatch line all around. A steel covered brow shall be provided at each of the above mentioned ceiling installations. Tank margin brackets ceiled in Holds No. 2, 3, 4 and 5 only
Cut off channel flg. for midship portion only
Margin Plate - .54" Holds and E.R. - .60" in B.S.
Tank Top Plating - .44" to .40" in Holds - .52" in E.R. - .58" in B.S.
Limber Holes 4"x2"
.52" to .44"
.58" in B.S.
.52" in E.S. increased under engine bed plates as required
Girder
C Strake 88" - .64"
B Strake 88" - .64"
A Strake 88" - .64"
OPEN FLOOR
Floors: .38" in Holds, .42" in E.R. and .48" in B.S. increased at tank ends to rule
Keel Pl. .88" throughout. Includes 10% increase over rule for docking
Gusset Pl. 15" in No.1 Hold - 12" elsewhere - .44", .50" in B.S. .38" in Holds - .42" in E.R. - .52" in B.S.
Center Girder 43½" x .54" to .46" .42" in B.S.
3"x.44" F.B. Stiffrs. (.50" in B.S.)
14"x24"
16"x24"
12'8"
Solid floors on every frame in engine room, under boiler stools under bulkheads and forward of ¾ L.
Partial solid floors to longitudinals in way of thrust. Solid floors on every 4th. frame elsewhere (10'0" maximum spacing
Bottom Shell .64" with 30" spacing to .45" at ends. ½ L to ⅔ L forw'd .6" Forw'd. of ⅔ L .75"

Fig. 1—Midship Section of Liberty Ship. Courtesy Marine Engineering and Shipping Review

in service and the variety of their location and extent is infinite. One rumor which might well be ended here is that once a crack starts in a welded ship, it invariably propagates rapidly into the surrounding structure. By far the greater portion of failures which do occur in welds or in plates are confined to relatively short distances. This is true even when such a local fracture is in important strength members where the application of full normal working stresses would be expected to cause propagation of the fracture.

Failures have occurred in practically all types of welded and partly welded ships, although most of the stories in circulation have to do with the Liberty type. It is only natural to expect that there should be more failures in this type of which so many units have been built. This large number of almost identical vessels permits statistical studies to be made from which reasonably reliable conclusions can be drawn. It is especially noteworthy that welded ships in which the only riveted connections are the shell seams are virtually immune to the extensive structural failures found in otherwise similar ships with welded shell seams. This is not due simply to the effect of the seams as crack stoppers, for there are extremely few cases of fractures propagating in such ships. No failures of a serious nature have been found in smaller ships, say under 300 ft. in length.

Extensive studies have been made by the technical staff of the American Bureau of Shipping in an attempt to correlate the failures with all the various factors which might possibly have a bearing on the subject. For example, contrary to impulsive conclusions based on rumor, it has been found that vessels built in shipyards located in warm climates are, if anything, more susceptible to fractures than those built in cold climates. This may have no significance, but it illustrates the somewhat baffling statistical results that have been reached in most of the investigations being done on this problem. At one yard it was found that failures reported in service were only in vessels built on the ways at the ends of the yard. This led to the thought that the additional exposure to wind might have some effect but it has also been suggested that the distance from these particular ways to the welding supervisor's office might be equally to blame.

The record for each shipyard has been studied and no clear correlation can be shown between failures in service and the time of year during which the ship was built nor the length of time between keel laying and launching.

Serious failures usually occur within the midship half-length of the vessel, where the normal service stress is naturally the highest. In the cargo ships, they are almost entirely in the upper deck, while in the tankers failure much more frequently occurs at the bilge. It is believed to be significant that very few cracks of any kind have been found in way of the machinery spaces, and those which have occurred have not propagated to a dangerous extent. The higher temperature prevailing in this vicinity seems to be the only reason which could account for this condition.

After a fracture has started, its progress does not necessarily follow the path of weakest structure, but is quite as apt to continue through a thick plate within an inch or two of a butt with a thinner plate. A fracture may progress from thin plate into much heavier plating, or across welded lap joints without interruption. Internal members across the path of fracture or local reinforcements such as headers between beams or frames seem to have no tendency to divert the crack, but are themselves broken in way of the fracture in the deck or shell, if they are attached by continuous welds. This, however, rarely occurs if the connection is intermittently welded.

Some fractures are confined to the weld metal of a poorly prepared or welded joint, although in most of the large fractures plate metal is principally involved. In every case which has been examined carefully the fracture has the appearance of a crack in a brittle material. The edges are perpendicular to the surface of the plating and usually exhibit a herringbone or chevron pattern. This is known as a cleavage type fracture. The larger failures have all been accompanied by a violent explosion-like sound. The conditions under which a major failure occurs have usually included heavy weather, low temperature and an abrupt discontinuity. There are, however, cases where there appears to be no other factor present than low temperature. It is quite often found that the temperature has been changing rapidly, even rising, in the period immediately preceding failures of that type, which may point to a stress introduced by reason of a difference in temperature between adjacent parts of the structure. A number of failures of this kind have been found in the lower decks of refrigerated ships where the service stress would be expected to be low and even where no apparent discontinuity existed.

It should be emphasized that the chart of casualties shown in Fig. 14 is based on ship-years, rather than on the number of ships, and does not indicate the recurrence of trouble in certain vessels. One of the unaccountable facts developed in these analyses is that one vessel may have had as many as five relatively serious failures over a period of perhaps two years, while others from the same yard built at about the same time have operated for an equal time without any trouble at all.

It is most significant that one yard built the Liberty ship with the shell seams riveted, all other connections including frames being welded, in such numbers that the statistical results could hardly be a mere coincidence. None of these vessels has sustained a major structural failure which endangered the safety of the vessel.

2. *Points of Origin of Failures*

It may be said that the origin of most cracks or fractures is a discontinuity, which may be either structural or metallurgical. Most of the structural discontinuities or notches have been eliminated by the rounding of corners, fairing in gradually where change of section takes place and by giving more attention to attaching secondary members or minor fittings to the hull in order to minimize stress concentration. The metallurgical discontinuities are usually the result of errors in workmanship, either in the fitting up of parts and preparation of joints for welding, or in the deposition of the weld metal itself. The records contain numerous examples taken from actual failures which show that edge preparation has been partly or completely ignored and welds which have penetrated only part of the thickness of the plates or which contain inclusions of slag or other foreign matter.

The opinion has been stated that the stresses built into a hull during construction would be gradually dissipated through the alternate hogging and sagging experienced in service, the implication being that if a vessel withstood a year or two of service without failure, it would be safe to assume that none would occur. If the first assumption is true, the problem then is not merely one of stresses, for the record contains cases of vessels which sustained their first casualties after as many as four years of operation. There is hardly a case of a fracture which does not involve either a structural notch or a defect in a weld. The presence of such a condition, which may exist from the construction period, is therefore a potential starting point for failure, even though it may not become evident for years.

It would be impossible in a paper of this kind to explore in detail all the failures which are on record, so that this discussion includes only those which have resulted in serious danger to the vessel or might easily have

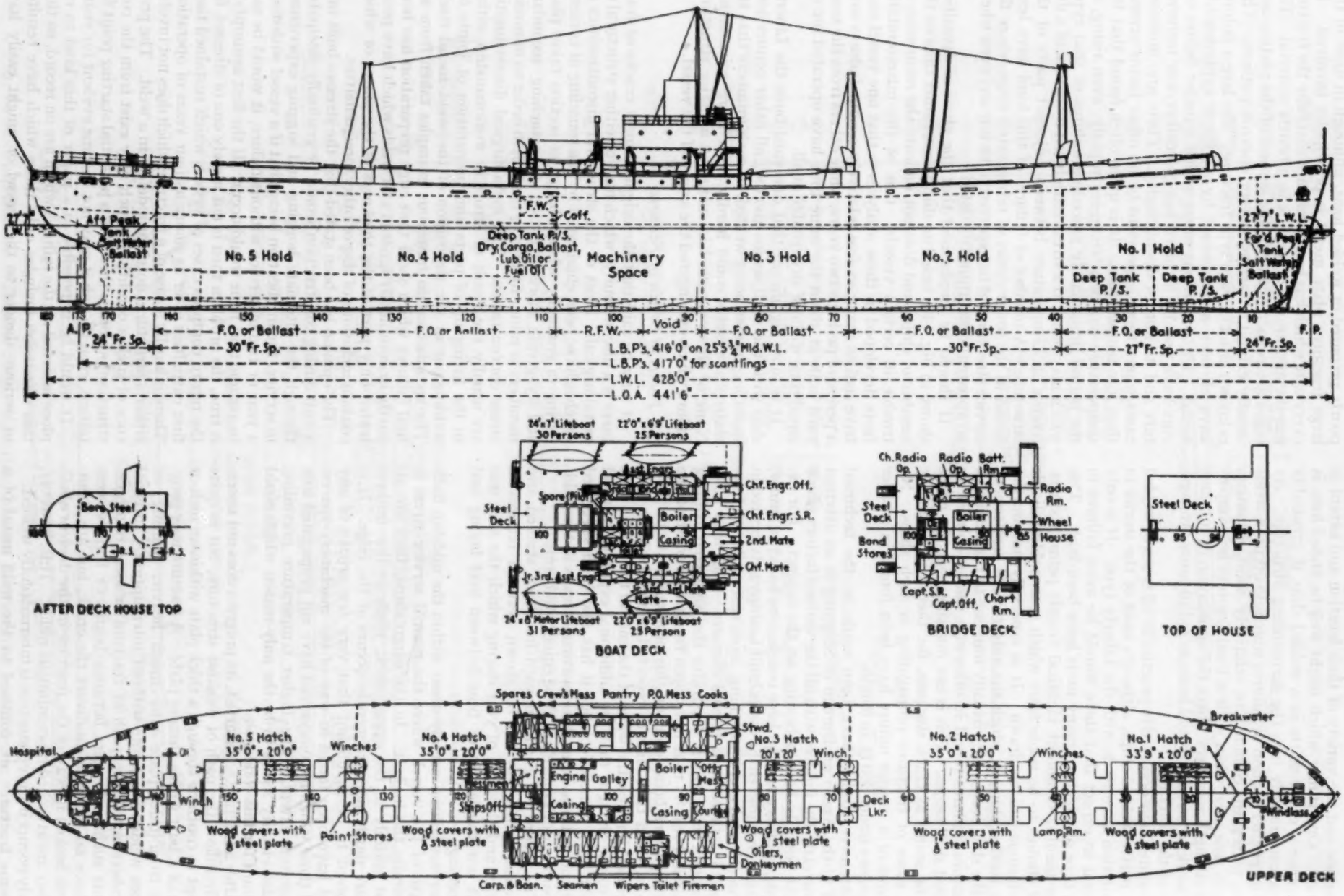


Fig. 2—Profile and Upper Deck of Liberty Ship. Courtesy Marine Engineering and Shipping Review

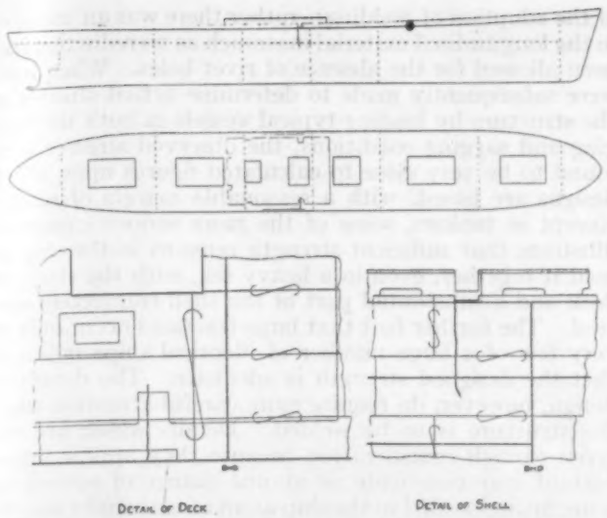


Fig. 3—Typical Failure in Deck and Shell Originating at Square Corner of Cut in Sheerstrake Made to Take Platform of Accommodation Ladder

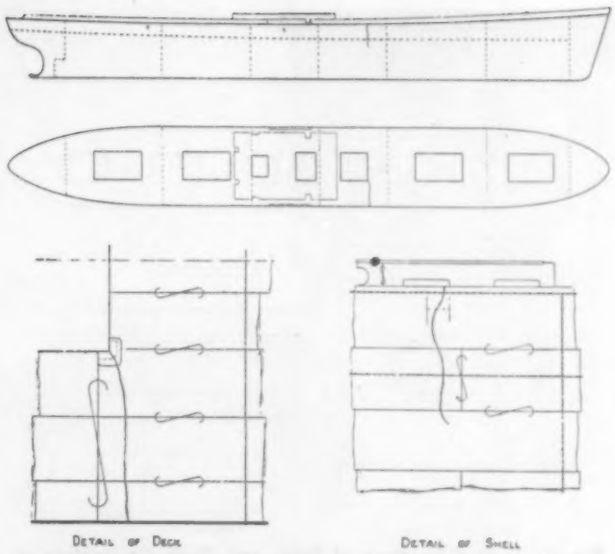


Fig. 5—Typical Failure of Deck and Shell Originating at Corner of Hatch

led to such a condition. Among the Liberty ships there have been 96 casualties which have been considered serious. Some typical cases are shown in the accompanying illustrations.

3. Fractures During Construction

In every shipyard there have been incidents of plates or welds cracking during the construction period both before and after launching. Records of these fractures have been kept with a view to discovering the possible causes of failures in service and it is found that certain comparable conditions surrounding failures in service are also present when difficulties arise during construction.

Most of these shipyard fractures are of inconsequential extent, but in rare cases an entire deck or hatch girder has fractured, the reasons for which are not altogether clear. They may occur in any part of the ship's structure, even in subassemblies, and are not confined to the midship half-length as are the great majority of failures in service.

There is a sharp increase in the number of fractures reported during winter weather. Usually, these are also found to contain some defect in workmanship, such as poor welds, unfinished welds, or accidentally burned notches.

Sometimes the area of the fracture has been subjected to careless application of heat for straightening or shrinking, or merely to keep the workmen comfortable. One serious fracture occurred in a ship which was nearly finished, while a heating stove was in operation in the hold. The deck and hatch coaming on one side of the ship fractured completely in the vicinity of the heated area.

Overwelding where fillets attach fittings, etc., occasionally results in cracks in the plate close to the toe of the fillet welds. In a few cases rough handling of subassemblies which were not adequately stiffened has produced fractures, and there is even one case of a completely fabricated hatch coaming which cracked practically from end to end while lying in storage in the yard.

It will be seen that fractures which occur during construction are similar to those which bring about failures in service.

If all possible precautions are taken while vessels are being built to avoid introducing the defects from which failures start, the possibility of casualties in service is proportionally reduced.

4. Repairs

The method of repairing many of the serious failures has been simply to close the crack to a reasonable open-

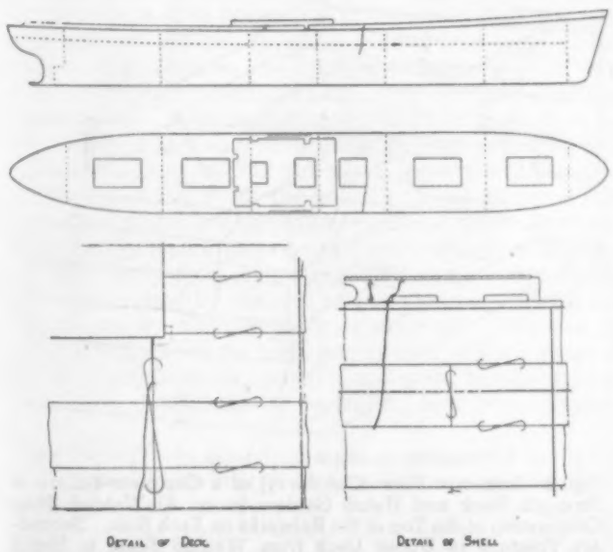


Fig. 4—Typical Failure of Deck and Shell Originating in Defective Butt Weld in Deck near Hatch Corner

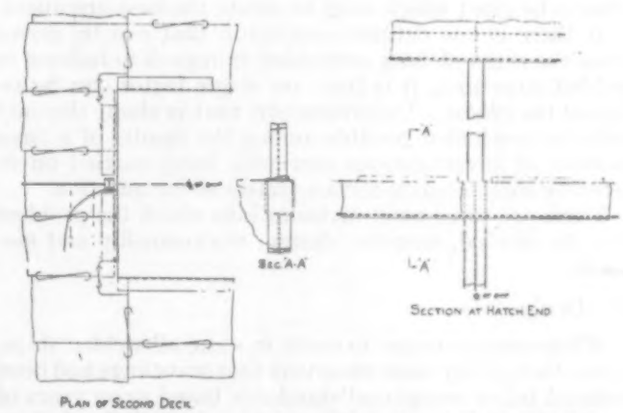


Fig. 6—Typical Fracture of Second Deck and Hatch-End Beam of Liberty Ship at Base of Centerline Pillar

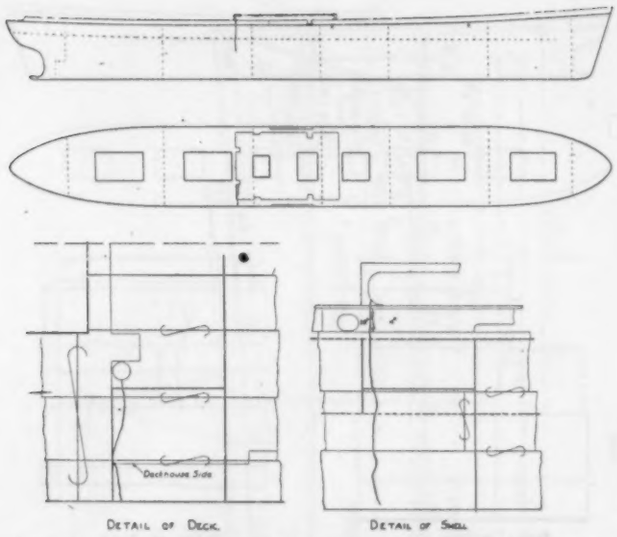


Fig. 7—Typical Fracture of Deck and Shell Originating in Deck Plating at After Corner of Deckhouse

ing by properly loading the ship, beveling the edges of the fracture, and welding. So far as known, no vessel which has been thus repaired has subsequently failed in the same vicinity, although there is one case of a vessel which cracked near amidships on one side and a year later cracked in an identical manner on the opposite side in spite of the fact that a careful examination of the opposite side was made on the first occasion. There is, on the other hand, no evidence to show that the removal and renewal of the damaged material restore the condition which caused the original failure. However, great care is necessary to make accurate fit-up of new members and to follow a suitable sequence of welding in order to avoid a condition worse than before the failure.

Repairs to fractures found during construction are governed by the location and extent of the damage, and the possibility of performing repair welds in a proper sequence. Usually, cracks confined to weld metal may be chipped out and the joint rewelded, while fractured plates are renewed, particularly if the fractures are irregular or close to welds.

Section II—Causes of Failures

Having examined the nature of the problem and found the most common points of origin of trouble, the various explanations of the cause or causes of these phenomena will be discussed, with a word of caution. A sound argument could be made for any of several causes by considering a few selected failures, but some other cases may always be cited which seem to refute the best argument.

If there is one definite conclusion that can be drawn from the mass of data assembled in regard to failures in welded structures, it is this: no single factor can be assigned the blame. Unfortunately, that is about the only definite conclusion possible among the results of a large number of investigations currently being carried on or recently completed on certain phases of the question.

There are three main divisions into which the problem may be divided, namely: design, workmanship and material.

1. Design

When failures began to occur in some all-welded ships, it was thought by some observers that scantlings had been reduced below recognized standards based upon years of experience with riveted ships. A review of the designs showed that there had been no departures in consequence of the adoption of welding; rather there was an increase in the longitudinal material inasmuch as no reduction had been allowed for the absence of rivet holes. When tests were subsequently made to determine actual stresses in the structure by loading typical vessels in both the hogging and sagging conditions, the observed stresses were found to be very close to calculated figures upon which designs are based, with a reasonable margin of safety. Except in tankers, some of the more serious casualties illustrate that sufficient strength remains in the ship to hold it together, even in a heavy sea, with the strength deck and a substantial part of the shell completely severed. The further fact that large fractures occur only in very few of a large number of identical ships indicates that the designed strength is adequate. The details of design, however, do require more careful attention when the structure is to be welded. Details which are not given enough consideration because they appear unimportant may constitute an abrupt change of section, or some fittings added to the ship as an afterthought may be potential trouble makers, although in riveted construction no special notice would have been given to them. Notwithstanding the modifications in design, which have greatly improved performance, some fractures do occur which cannot be attributed to design features, so that one must seek other causes as well.

2. Workmanship

Workmanship has been the most obvious contributing factor in failures, and more effort has been put into improving it than any other phase of the problem. Present methods of inspection in general use being far from conclusive as to the soundness of welds, it is essential that a will to good workmanship be instilled into the personnel and every step taken which will make inferior welds unlikely. Fortunately, the very numerous small and inconsequential cracks found from time to time in vessels which have been in service demonstrate that these imperfections only lead to disastrous results when accompanied by other adverse conditions. Nevertheless, as stated earlier, in many of the large failures, an imperfect weld has been the point of origin. The imperfections are as often in the manner of preparing the joint for welding as in the quality of metal deposited.

Unless there is to be a return to riveting, methods of inspection which give assurance of sound workmanship should be used more extensively. It has been found re-

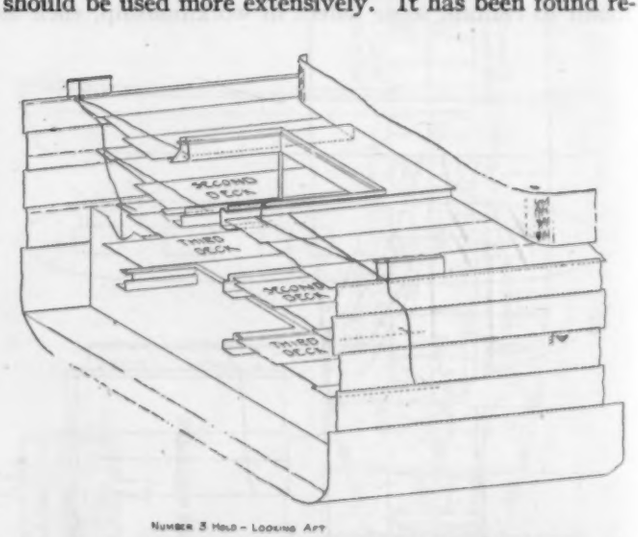


Fig. 8—Isometric View (Cut Away) of a Complete Failure of Strength Deck and Hatch Girders in an All-Welded Ship, Originating at the Top of the Bulwarks on Each Side. Secondary Fracture in Upper Deck from Welded Seam to Hatch Coaming. Fracture in Coaming with Branch Crack in Deck Joining Secondary Fracture. See also Fig. 9

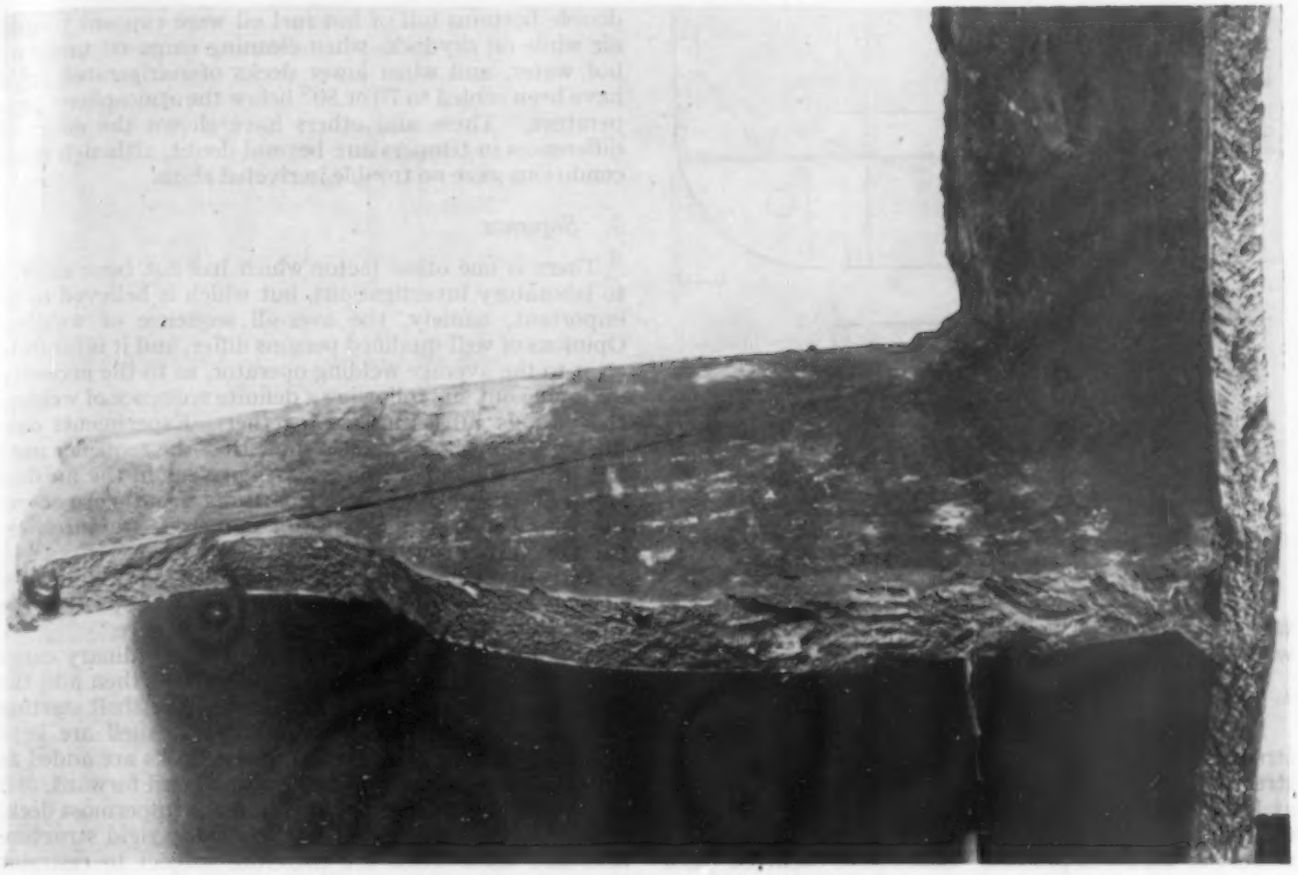


Fig. 9—Specimen from Upper Deck and Hatch Coaming, Port Side, Looking Forward, of Vessel Shown in Fig. 8. Chevron Pattern on Fractured Surfaces Indicates Left-Hand Fracture Started Outboard, Vertical Fracture Started at Bottom of Coaming and Near Fracture Started at Coaming and Joined Left-Hand Fracture

peatedly that the mere initiation of a thorough system of subsurface inspection resulted in marked improvement in weld quality.

3. Material

A great deal has been said concerning the properties of steel as a suitable material for building welded ships, particularly with reference to its resistance to impact. Since almost identical ships built with some riveting have exhibited none of the tendency of their welded sister ships to crack, it is necessary to conclude that the material behaves differently when welded into large structures, or that stresses are sometimes introduced of sufficient magnitude to cause failure when other conditions are favorable. Extensive tests have been carried on to measure these stresses, with some success, but although tensile stresses exceeding the yield point were found in the vicinity of the weld, the balance of the material was found to be under low compressive stress, below 9000 psi.

It is known that a large welded steel structure does behave differently from one which is riveted, owing to the restraint imposed by the size of the structure, which becomes virtually a single piece of material. The loss of ductility and ability to yield plastically in local areas of high multiaxial stress, with consequent brittle failure under such conditions of restraint, has been demonstrated.

The capacity to absorb energy, as measured by notch impact tests, of ordinary ship quality steel is known to vary from a satisfactory value to a low value within the range of temperature in which ships operate. The definite relation between failures during construction, as well as in service, and the atmospheric temperature, leaves little room for doubt that this property of steel has a bearing on the problem. It has also been found that the difference between a steel having good notch impact values and one much less notch tough is the result of factors not usually disclosed by ordinary tensile tests, and the temperature at which toughness gives way to brittleness is only determined by a series of tests. This individuality of steels of the same mechanical properties may account in some measure for the fact that some ships fail for no apparent reason while others undergo extremes of operating conditions without mishap. It is generally believed that ship steel with uniformly higher notch impact values than the present average range would be desirable for

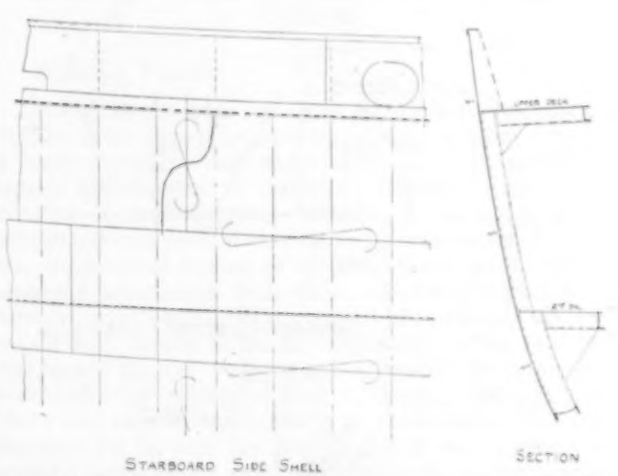


Fig. 10—Typical Fracture During Construction, in Sheerstrake

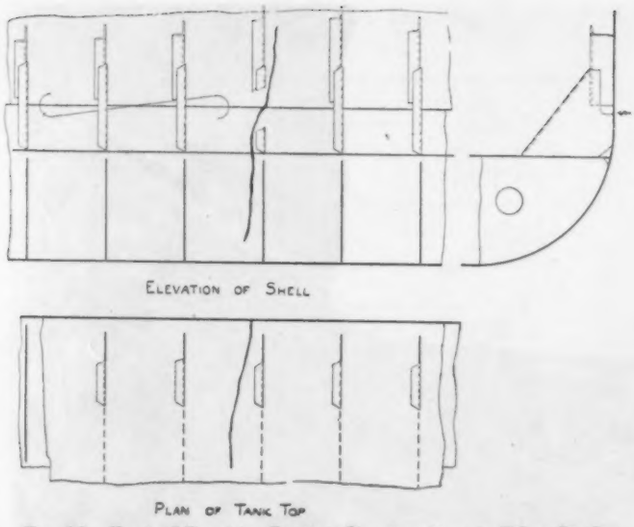


Fig. 11—Typical Fracture During Construction, in Bilge Strake and Tank Top

welding purposes, if it could be obtained without loss of weldability.

4. Temperature

Difference in temperature between parts of a welded structure as large as a ship can result in very appreciable stresses. In the presence of imperfections, and especially at lower temperatures where impact value is low, fractures have occurred which propagated extensively when no service load was present. Cases have occurred when double bottoms full of hot fuel oil were exposed to cold air while on drydock, when cleaning cargo oil tanks by hot water, and when lower decks of refrigerated ships have been cooled to 70 or 80° below the atmospheric temperature. These and others have shown the effect of differences in temperature beyond doubt, although those conditions gave no trouble in riveted ships.

5. Sequence

There is one other factor which has not been subject to laboratory investigations, but which is believed to be important, namely, the over-all sequence of welding. Opinions of well-qualified persons differ, and it is far from clear to the average welding operator, as to the necessity for laying out and following a definite sequence of welding the various subassemblies together. Experiments conducted with full-size panels show that the sequence used has little effect upon the stresses present in the finished subassembly. However, departures from correct sequence have been the cause of numerous fractures, especially during construction.

A distinction should be made between welding sequence as applied to subassemblies and as applied to the whole ship. The latter will be considered here.

The present system of erection in the ordinary cargo ships is to weld almost the entire bottom, then add the double bottom sections, and next the side shell starting from amidships. The lower strakes of shell are kept ahead of the upper strakes, and the decks are added as the work progresses upward, outward and forward, and aft of amidships. The result is that the uppermost deck, bulwarks, etc., are welded to the already rigid structure last, and these welds are therefore subject to restraint

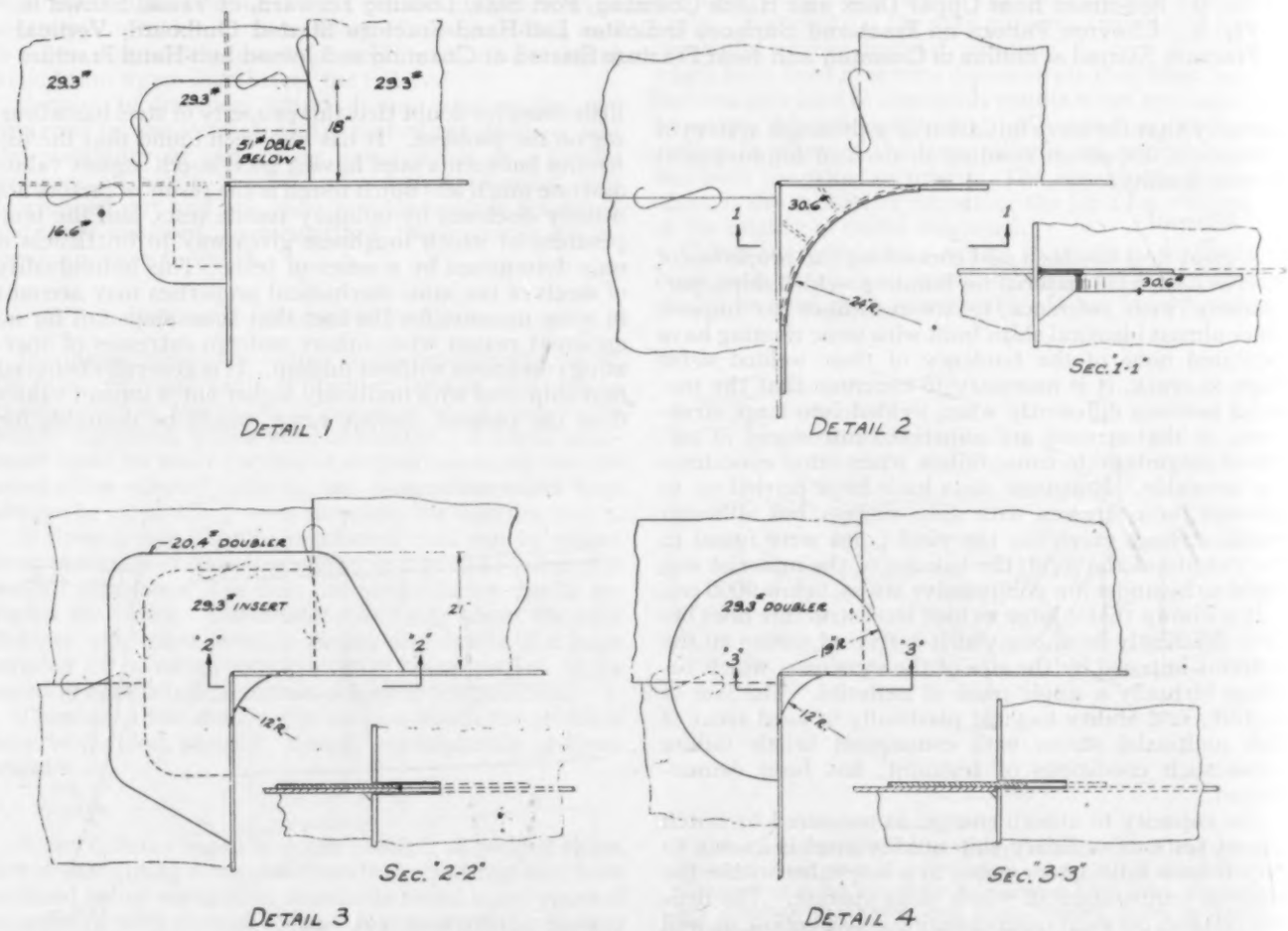


Fig. 12—Details of Hatch Corners

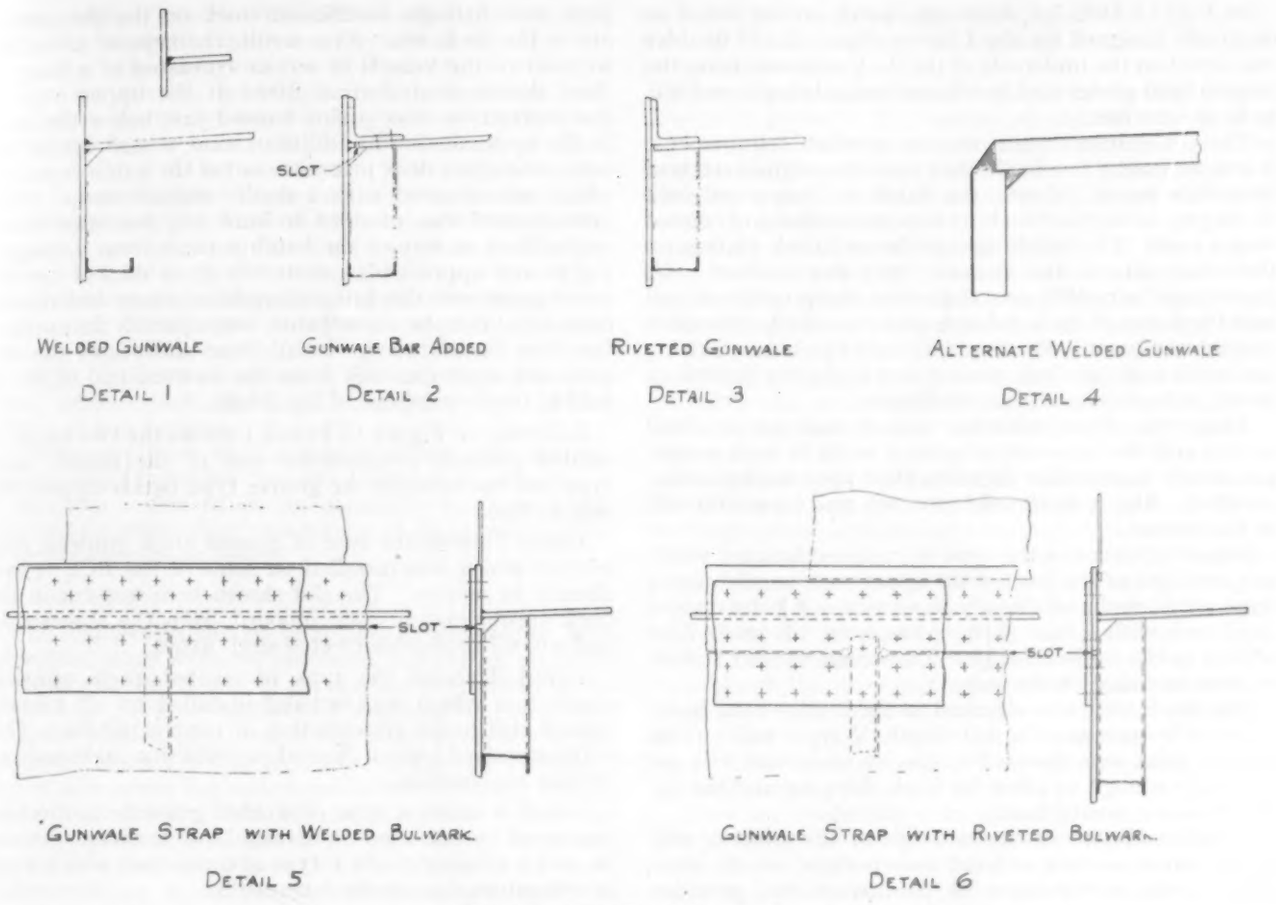


Fig. 13—Details of Gunwale

upon cooling. In extreme cases, buckling of the bottom has occurred when this stage of construction was reached. In the tankers it is usual to fit the bilge assembly last. Both of these methods are the result of practical considerations of erection and accessibility during construction, which cannot be ignored. Nevertheless, there are bound to be local areas of high stress concentration in the final, restrained welds, which frequently cause shrinkage cracks or less perceptible metallurgical upsets. These metallurgical upsets are the notches which originate a failure under certain service conditions since the records clearly show their presence at the point of origin in a great majority of cases. However, those vessels in which the side shell seams are riveted, although built of the same material, following the same sequence of erection, and otherwise entirely welded, do not present the same condition since the horizontal riveted joints permit sufficient readjustment to prevent the accumulation of restraint.

Even in the same yard, the variation in welding sequence as between vessels has been considerable in some cases, and being subject to limited control, no accurate record exists of the exact sequence followed for a particular ship. Probably the data would be so voluminous as to defy analysis if it were known, but it is safe to assume that the stress patterns resulting from welding are slightly different for each ship, and the unpredictable incidence of failures would be consistent with this assumption.

The absence of serious failures in the smaller vessels may be due to the much smaller degree of restraint imposed by a shallower depth, less accumulation of shrinkage by reason of the smaller number of welds, as well as to the better impact properties of thinner material and its tendency to buckle, affording relief to internal stress. That the tendency to produce areas of tension stresses at the top is present even in small ships is shown by the lifting of the ends from the keel blocks during construction.

It would seem logical to modify methods of erection so that the areas welded last were in the vicinity of the vessel's neutral axis, or to construct whole belts of ship with all attachments in place and join them by girth butts, in the same manner as a large cylindrical pressure vessel. The first yard layout proposed for building welded ships, although never carried out, was intended to make use of precisely the latter method.

Section III—Measures Taken to Avoid Structural Failures

1. Existing Vessels

During the winter of 1942 to 1943 the failures in welded ships began to increase at an alarming rate and it became evident that steps had to be taken quickly to reduce the number of failures. By that time a large number of the emergency or Liberty vessels had been completed and were in service and it was necessary to devise a practical means of altering these ships, without seriously interfering with their schedules, which would prevent or at least limit the extent of failures of the type which had begun to occur frequently. The first step was to add curved brackets at the level of the upper deck inside all four corners of Nos. 2, 3 and 4 hatches. The Navy had already made this type of alteration on vessels acquired by it, and the Navy's detail was adopted and ordered installed as soon as possible in existing vessels and in those which were nearly completed.

In Fig. 12 Detail 1 shows the hatch corner detail as originally designed for the Liberty ships. A 51# doubler was fitted on the underside of the deck as shown here, the longitudinal girder and hatch end beam being coped out to fit the doubler.

The 29.3# insert plate was an erection requirement; it was necessary due to the fact that the original erection procedure was as follows: the hatch end beam and deck plating up to the erection butt were assembled and erected —as a unit. The hatch side girder and deck plating on the other side of the erection butt was another unit. Now it can be readily seen that when erecting this second unit the flange of the hatch side girder would foul the deck plating of the unit which was already in place. Cutting out a piece of the deck plating and replacing it with an insert plate eliminated this confliction.

This type of construction was of such an involved nature and the necessary overhead welds in such a comparatively inaccessible location that poor workmanship resulted. Also a small void or notch was invariably left at the corner.

Detail 2 illustrates the type of radiused bracket which was installed at the level of the upper deck on all Liberty ships completed and already in service. It consists of a 30.6# web with a face plate of the same thickness fillet welded to the radiused edge. Two small flat bar stiffeners were installed on the web.

The whole unit was attached to the inside of the hatch coaming by means of a full depth V-type weld. This type of joint was chosen because its underside was not accessible enough to allow for back-chipping and the application of a closing bead.

Detail 3 illustrates the redesign of the Liberty ship hatch corner as was ordered incorporated on all ships either under construction or contracted for, provided the parts had not already been fabricated.

Here the 29.3# insert plate was retained as in the original design except that instead of having a square corner it was provided with a 12-in. radius fillet inside the corner of the hatch. A 20.4# doubler of comparatively ample dimensions was fitted on the top side of the deck; the inside corner was radiused in the same manner as the insert plate. The hatch coaming was slotted at the deck level and the fillets of both the deck insert plate and the doubler extended through the slot in the coaming, the edges of both plates being beveled to form a single vee weld. The doubling plate could be either riveted or welded at the option of the shipyard.

Detail 4 shows an alternate design which was adopted by two of the yards building Liberty ships. Here, due to different methods of erection, the insert plate was not necessary and it was eliminated. The doubler was of 29.3# plate. As in the previous case the hatch coaming was slotted but only the doubler extended through this slot. In one yard the edge of the doubler was riveted and in the other it was welded.

In the latter two designs the wide comparatively lightweight doublers were substituted for the narrow 51# doubler of the original design.

It was clear from the failure studies that a brittle fracture would not cross a riveted joint, even though it propagated at high speed. The most dangerous condition resulting from failures was the severing of the strength deck and side shell through the rapid propagation of a fracture starting in either of those members. In order to limit the break to the member in which the failure started, i.e., either the upper deck or the side shell, a riveted connection between the upper deck and shell was introduced by means of a double-riveted angle, such as is commonly used in riveted construction. This proved somewhat inconvenient to fit on existing vessels, owing to the interference from vent and overflow pipes, scuppers, deck fittings, insufficient stock on the sheerstrake above the deck, etc. As a result, the type of alteration to most of the vessels in service consisted of a longitudinal double-riveted strap fitted at the upper edge of the sheerstrake over a slot burned just below the level of the upper deck. In addition, some vessels had a slot cut in the upper deck just outboard of the hatch coamings which was covered with a double-riveted strap. This arrangement was intended to limit any fractures which might start in way of the hatch corners from propagating to any appreciable extent. A great deal of controversy arose over this latter alteration; many individuals considered it to be superfluous, consequently its application was discontinued. In all these alterations the slot extended approximately from the forward end of No. 2 hold to the forward end of No. 5 hold.

Referring to Figure 13 Detail 1 shows the two types of welded gunwale connections—one of the double fillet type and the other of the groove type back-chipped and seal welded.

Detail 2 shows the type of riveted angle gunwale connection which was installed on some of the EC2 vessels already in service. The slot shown here was cut in the deck approximately 1-in. inboard from the sheerstrake and a 6- x 7-in. double-riveted angle fitted.

Detail 3 shows the type of riveted angle gunwale connection which was ordered installed on all Liberty vessels still under construction or contracted for. This is the standard type of riveted construction and needs no further explanation.

Detail 4 shows a type of welded gunwale connection employed by one yard on several large tankers. As can be seen it eliminates the T-type of connection which some investigators claim to be detrimental.

Details 5 and 6 show alternate types of riveted connections. They are intended for installation on existing vessels where the use of the riveted angles would involve interference with the air pipes, scuppers, etc.

This consists principally of burning a slot though the sheerstrake and reconnecting the two pieces thus formed with a double-riveted strap. Most yards building EC2 vessels welded the bulwarks to the upper edge of the sheerstrake and for these vessels detail 5 applies.

There were, however, one or two yards which for one reason or another preferred to rivet the bulwarks to the sheerstrake. For these vessels a slight modification in this detail was found necessary due to the fact that there is insufficient space for two rows of rivets between the bottom of the bulwark plate and the deck plating. Consequently the slot was burned at a low enough level to allow one row of rivets between it and the deck plating, which resulted in the slot fouling the faying flange of the shell frames. In order to overcome this difficulty the slot was terminated in drilled holes immediately adjacent to the toes and heels of each frame.

Some of the conditions present at locations where fractures were known to have started could be easily changed to minimize the possibility of cracks starting and this was also done on existing vessels. The butts in bilge keels were often poorly welded or welded without regard to the fundamentals of proper sequence; so that if the weld metal in the butt fractured, in all probability the crack would extend into the adjacent shell plating. The same condition existed at the butts of the bulwark rail and the butts of the bulwark plating. In all these cases it was therefore necessary to cut a small scallop so that the ends of the butt welds did not come in contact with the adjacent member. As a further precaution, the bulwarks were redesigned so that they were attached to the sheerstrake only in way of the bulwark brackets.

This alteration was incorporated on subsequent vessels still to be constructed under existing contracts.

In the original design of the EC2 vessels the fitting of the accommodation ladder platform necessitated that the sheerstrake be cut down in way of it. The detail of this cut not having been indicated on the structural plans, it was made with square corners from which several major failures began. The corners of this cut were subsequently rounded and except for one case of a very careless cut in making the radiused corners no more difficulty was experienced at this location. It was even found that some fractures started from large circular openings in the upper deck which were cut for ventilators and were located very close to the midship deckhouse, and accordingly doublers of sufficient size and thickness were fitted around these openings eliminating any further trouble of this nature.

Corrective measures of a similar nature were also applied to vessels of other than the Liberty type in so far as it was practicable to do so, especially in those which were not completed but were too far along in construction to permit changes in design.

2. New Vessels

The changes in design indicated by experience with all-welded ships were not profound, but rather consisted of modifying the layout of parts so as to conform to the somewhat different method of construction employed with the welded ship, and giving strict attention to the geometry of intersecting members. It became necessary, and is now usual, for seams and butts of plating, the extent of beams and girders, etc., to be laid out with a view to making up subassemblies of conveninent size which can be joined on the shipways with a minimum of work. Subassembling is, of course, advantageous from the standpoint of sound welding, irrespective of production schedules. The accessibility of all joints for proper welding is of paramount importance and therefore is given careful consideration, both as to subassemblies and final connections on the shipways. When these phases of the design have received due attention, it becomes fairly easy to develop a sequence of erection and welding which will be practical for the shipfitters, satisfactory to the welding superintendent and result in a structure that is reasonably fair.

The details are now planned to provide large radius corners at every opening, to locate abrupt changes of section away from concentrations of welding, and to eliminate small insert plates. Non-watertight members are scalloped out to clear welds in other members which they cross, and some connections are avoided altogether where possible, such as welding the lower edge of the bulwark plating to the upper edge of the sheerstrake.

Since light members such as bulwarks and bilge keels are not ordinarily considered strength members to the hull structural girder, the folly of attaching them thereto by means of continuous welding should have been obvious. If rigidly connected as by welding they cannot be prevented from acting as part of the hull girder and being subjected to stresses far in excess of their capacity. This is particularly true in the above-mentioned cases where the lighter member is attached to the extreme fibers of the hull girder cross section.

Where local reinforcing is required in a welded vessel the entire plate in the vicinity should be increased in thickness, and to be proper the excess of thickness must be chamfered, to match the thickness of adjacent plates, where they join. Only by such means can good welded design details be evolved.

A study of all hatch corner failures on the Liberty ships indicated that in a considerable number of these the fracture would extend inboard of the line of the hatch side girder and run parallel to the hatch end beam for a distance of several inches. The break would generally be in either the weld metal of the fillet attaching the hatch end coaming to the deck, or along the line of the fusion zone between this fillet weld and the deck plating.

The geometry of the deck structure is such that at the hatch corner there is a very abrupt change in section in the longitudinal deck girders which are in line with the side of the hatch opening. In way of the hatch these girders have a very deep web due to the hatch coaming being integral with the web of the deck girder. Clear of the openings there is, of course, no hatch coaming and the depth of the girder web is comparatively shallow.

Although the principal function of these girders is to carry local deck loads it must be admitted that as long as they are welded to the deck plating they will absorb some of the stress caused by the hogging and sagging of the hull girder.

Therefore to eliminate the abrupt change in section in this girder at the hatch corner it is now general practice where this condition exists to carry the web of the side coaming beyond the end of the hatch for approximately one frame space and to taper it down from the top of the hatch coaming to the deck. A face bar is fitted along the free edge of this bracket. Alternatively, of course, the former type of raised deck between hatches as used in riveted ships is particularly effective in this respect.

Other factors are, however, still present, and further

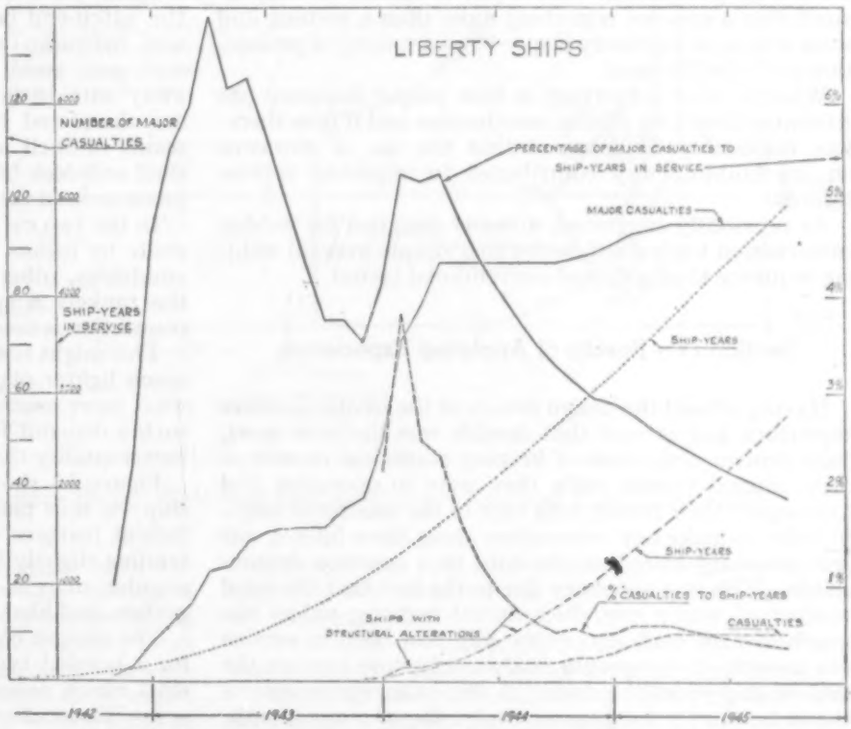


Fig. 14—Chart of Failures in Liberty Ships, Showing Effect of Alterations

education of welding operators and supervisory and inspection personnel is necessary. Much progress has been made in this direction, however, through the efforts of the various agencies interested in the quality of the work, by means of booklets of instruction, posters, advanced training courses and the like.

Methods of inspection are being extended to supplement the usual visual method, which is of very little value in detecting defects, once the work is completed. X-ray and gamma ray inspection are being used more widely to check finished welds in important locations and have a decided advantage over trepanning in that no repairing is necessary. Plugs or probes are valuable, however, as a means of conveying directly to the personnel responsible, the quality or lack of it found in welds, without the need of interpreting the results, for which special training is required as in the case of radiographs.

There remains the elusive force which causes some fractures to propagate to a dangerous extent, and as it cannot be expected that all minor defects in workmanship where cracks can start will be eliminated or even detected, provision must be made to guard against these. Some small cracks from time to time must be expected, just as a few defective rivets would be in a riveted ship. Excepting small vessels, new designs have nearly all incorporated some riveting, usually in the form of a gunwale angle, to confine fractures to the member in which they originate, and, it is hoped, to remove at least to some extent the cause of such failures, by eliminating residual welding stresses in this connection which is also subject to high service stresses. The length of the gunwale angle is slightly greater than the midship half-length, and forward and aft of that the connection is welded. In vessels of which the side shell seams are riveted, the gunwale is still welded.

Sequences have been given considerable attention, and research to date shows them to be unimportant in panel fabrication. They are necessary to control distortion and to some extent to control of production, although it is admittedly difficult to enforce rigid adherence to a fully detailed sequence if speed is the paramount consideration in production. However, it should be emphasized that a squence is nothing more than a system, and some system is necessary if speed and economy of production are to be obtained.

What is most important is that proper sequence has minimized cracking during construction and it may therefore reasonably be assumed that the use of sequence on the building way contributed to improved service records.

As previously suggested, a vessel designed for welded construction lends itself better to a simple over-all welding sequence than a ship of conventional layout.

Section IV—Results of Applying Experience

Having altered the design details at the locations where experience had proved that trouble was likely to start, there remained the task of keeping statistical records of these altered vessels while they were in operation and to compare their record with that of the unaltered ships. In order to make any comparison along these lines it was first necessary to reduce the data to a common denominator. This was necessary due to the fact that the total number of major casualties meant nothing unless the length of time each and every ship had been in service was known. Consequently the records were kept on the basis of ship-years of service. A ship-year represents one ship in service for one year, or twelve ships for one month, etc. In other words, to get the total number of ship-years, the total number of ships in operation is multiplied by the total number of years these ships have been in service.

Figure 14 shows the record of all Liberty vessels since the inception of the EC2 program in the middle of 1942. The light dotted line shows the ship-years in service.

The light solid line shows the total number of major casualties at any particular date. The curve shows cumulative totals and illustrates the sharp rise in casualties which was experienced between the fall of 1942 and the winter of 1943–44. At this time the effect of the various structural alterations was beginning to be felt and we see this curve beginning to level off considerably.

The heavy solid line shows the percentage of major casualties to ship-years in service and clearly illustrates how the peaks occurred during the winter months.

The dot-dash line shows the ship-years in service of all ships with structural alterations and the dash line shows cumulative major casualties for these ships.

The heavy dash line shows the per cent of major casualties to ship-years in service for ships with structural alterations. This curve shows a pronounced peak during the first winter in which the ships with structural alterations were in service. This peak was caused by one major casualty and is so pronounced due to the relatively small value of ship-years.

Since the importance of the various measures mentioned was demonstrated so clearly by the record of ships in service, some new designs have been developed which have reached the stage where there is a substantial number of vessels in operation. These are the Victory ships, the 320-ft. cargo ship known as C1-M-AV1, and the 541-ft. tankers referred to earlier. (There are, of course, others, but they have not been built in comparable numbers, so that statistical comparisons might be misleading.)

These vessels were designed with a view to all-welded construction, the arrangement of members being made suitable for subassembly and a simple welding sequence. Details were worked out most carefully to provide those safeguards which were found necessary by experience with the earlier ships. Hatch corners have long radii, both at the deck level and at the underdeck flanges of the hatch-end beams and side girders where they intersect, bulwarks (where fitted) are detached, bilge keels are scalloped, small inserts and doublers have been done away with in favor of thicker plates whose boundaries are chamfered to match the surrounding plates. The seams of shell are kept clear of the tank top margin; shell and deck butts generally match to form single girth joints around the entire ship.

In the two cargo ship types, the gunwale connection is made by means of a double-riveted angle for $^3/_5$ length amidships, otherwise, they are welded throughout. In the tankers a special detail which eliminates the Tee connection is used as shown in Fig. 13, Detail 4.

This might not be practicable for use on vessels having much lighter plating but since the detail requires somewhat more exact fitting than alternatives it may be that such a demand for careful fit-up automatically provides better quality than would otherwise result.

Figure 15 shows the midship section of the Victory ship; a ship planned and built for welded construction. Salient features are the double-riveted gunwale bar extending slightly beyond the midship one-half length, the angular margin plate, construction of the hatch side girders, and liberal use of snipes throughout the structure.

The margin plate was knuckled to avoid the necessity for a beveled type of weld between the margin and the shell which necessitated back-chipping in an almost inaccessible location with resulting poor workmanship.

Note that the longitudinal deck girders in line with the

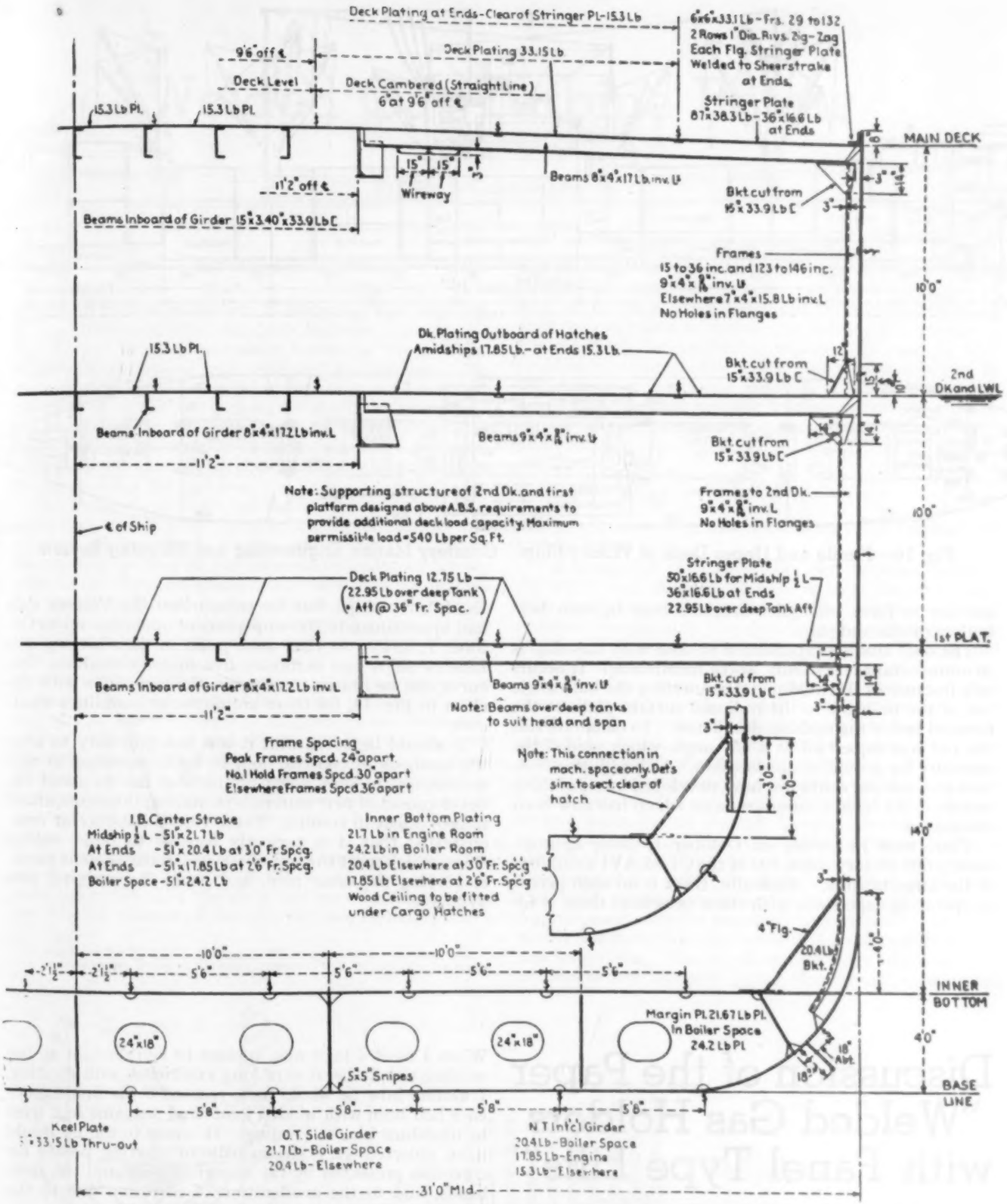


Fig. 15—Midship Section of Victory Ship. Courtesy Marine Engineering and Shipping Review

sides of the hatches are not built integrally with the hatch side coamings. This system allows the cutting of an ample fillet in the deck plating at the corners of the hatches without having to resort to slotting the hatch coamings as it was necessary to do on the Liberty ships.

Note that all frames, non-watertight floors, deck beams, etc., are scalloped wherever they cross a welded seam be it in the deck, shell or tank top.

Although not indicated at this particular section the bilge keel is scalloped at all butts both in the shell and the bilge keel itself.

At the ends of the vessel the strakes were laid out so that the margin plate would not cross any shell seam.

Figure 16 shows the inboard profile and main deck arrangement plan of the Victory ship. The continuation of the longitudinal hatch coamings beyond the ends of the

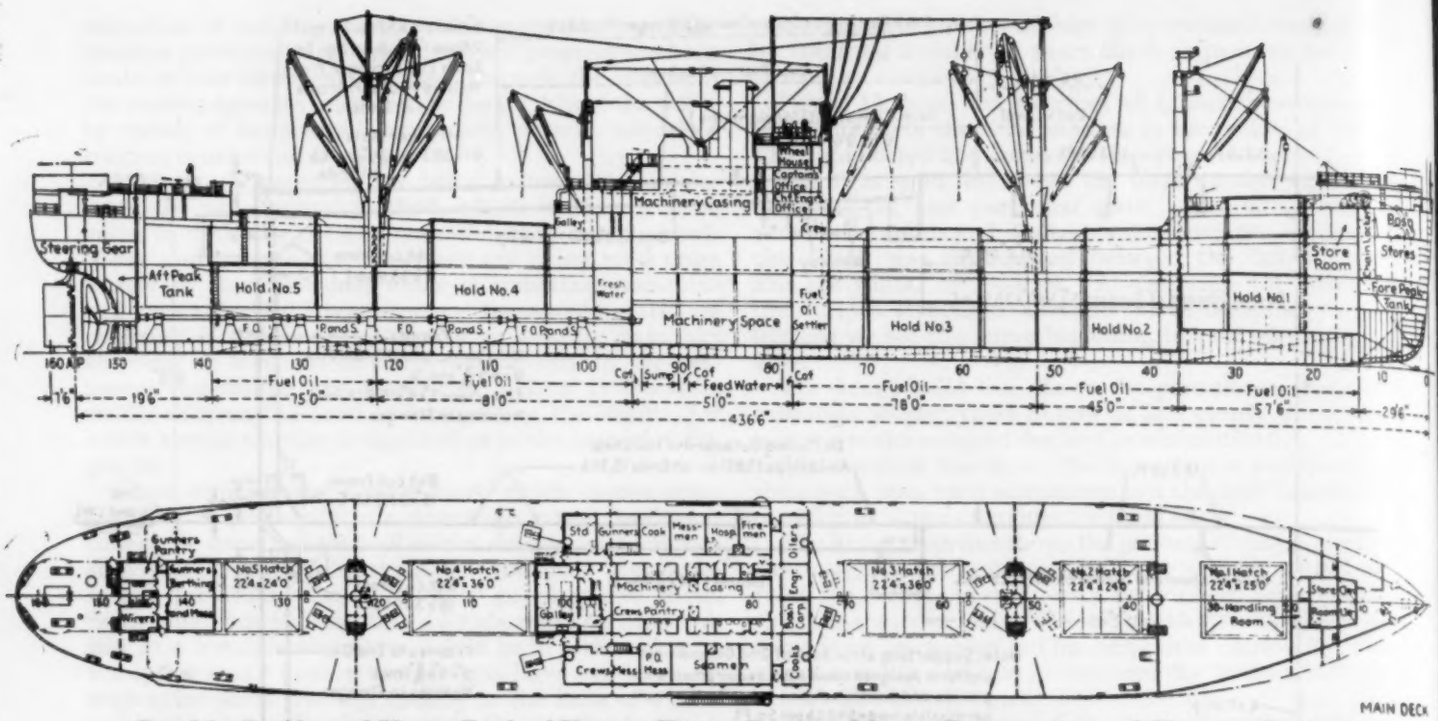


Fig. 16—Profile and Upper Deck of Victory Ship. Courtesy Marine Engineering and Shipping Review

hatches to form triangular brackets may be seen here both in profile and plan.

The only trouble experienced to date with this ship is so unimportant it is hardly worth mentioning. It occurs as a fracture in the weld metal connecting the bulb angle rail of the bulwark to the radiused curtain plate at the forward end of the midship deckhouse. To eliminate this the rail was sniped off at a 45° angle which voided the necessity for a weld in this location. Although this fracture was not and could not have developed into anything serious it did have a nuisance value which has now been eliminated.

There were in service on October 1, 1945, approximately 509 Victory ships, 192 of the C1-M-AV1's and four of the large tankers. Naturally, there is no such period of operating experience with these vessels as there is for the Liberty ships, but for comparison the Victory ship had approximately 200 ship-years of operation up to October 1, 1945. At that same point in their history, the Liberty ships had sustained five major casualties. No curve can be drawn to compare the new ships with the chart in Fig. 14, for there are no major casualties whatever.

It should be noted that it was not necessary to alter the methods of construction, to train personnel in new techniques, to slow down production, nor to await the development of new materials in making this pronounced improvement in results. These vessels have so far demonstrated that it is perfectly feasible to build welded ships, which meet the test of service, in our present yards, employing the same men, and using the material now available.

Discussion of the Paper "Welded Gas Holders with Panel Type Lifts"*

By R. B. Lincoln†

I HAVE read the paper (Welded Gas Holders with Panel Type Lifts) with much interest. I am particularly impressed by what he has to say about corrosion because it parallels my experience with pressure vessels and structures exposed to the weather. When I meet a man who appears to be reluctant to use welding simply because of long experience with riveting, I wonder how he would have reacted if his first experience had been with welded joints and someone had tried to introduce him to riveting. It seems to me he would have objected very strenuously to starting points for corrosion presented by the imperfect joint and the rivet heads, and to the acceleration of corrosion due to the stress concentration at the rivets.

In the qualification tests, the idea presented by Mr. Kraus whereby complete tests of defective welds are avoided by a preliminary examination has, in my opinion, merit for field work where new men are being hired. We have not used it because we feel that we are in a position something like an impartial judge and we cannot report a man has failed without complying with the letter of the code. Further, the set up in the laboratory permits rather rapid machining so that time might be actually lost by a preliminary test.

* Published in the Dec. 1945 issue of THE WELDING JOURNAL.
† Director of National Weld Testing Bureau, a Division of Pittsburgh Testing Laboratory, Pittsburgh, Pa.

Welded Gas Turbine Rotors*

By John F. Cunningham, Jr.†

Introduction

GAS turbine rotors run at extremely high temperatures and relatively high loadings and are subject to the phenomenon known as "creep"; that is, growth under load with time and temperature. Because of this condition, it is impossible to use the classical method of shrinking disks on shafts to assemble a gas turbine rotor, because the disks would eventually loosen in their fits with the shaft and cause erratic operation of the turbine. This condition made a problem for the designers of gas turbines.

The materials used for gas turbine rotors do not, as a class, cast well in large sizes, so the use of castings was rejected. Large steam turbine rotor drums have been forged, but because of the extreme difficulty of forging high-temperature materials this method was not feasible for the manufacture of gas turbine rotors. The only favorable looking method of fabricating rotors for this type of equipment was to assemble a number of disks into a rotor through some method of attaching the disks directly one to another. A review of various methods of fastening the disks together led to the adoption of welding, as this was the only fastening which was not necessarily highly stressed and would not lose its efficiency through relaxation during operation of the machine. Welding had been used previously in the fabrication of turbine rotors with considerable success so this method was adopted for the fabrication of the Elliott gas turbine rotors.

As the design of the Elliott gas turbines approached completion, it was found that it would be necessary to weld the rotors after the disks had been finish machined and bladed, because of the type of blade fastening which was required. It is this fact that made this job unusual. Because all parts of the rotor, with the exception of stub shafts were finish machined, it was necessary to weld the rotor with no measurable welding distortion of a quantitatively unpredictable nature. As soon as this problem was recognized, a test program was begun to test designs of joints and methods of fabrication which would give the least possible welding distortion and distortion only of a predictable nature.

Joint Design

Figure 1 shows a section view of an Elliott welded gas turbine rotor.

For a number of reasons the joint between disks in the rotor was designed to have a large circumference. This design imposed very low unit load on the weld and reduced considerably the problem of weld inspection. Because of this very low loading, a very small weld could be used with its consequent small amount of distortion. However, tests were made in mock-up disks of similar size and geometry to those used in the rotor and the distortion in these tests was felt to be higher than could be tolerated. Work was begun on the design of a joint preparation which would reduce distortion. The theory behind this joint design was to have a relatively flexible section between the weld and disk proper. This characteristic was achieved through having grooves cut in the parent metal at each side of the welding groove; thereby allowing the lip which contained the weld to bend during shrinkage of the weld. Tests made on small pieces with this weld preparation indicated that it was a distinct improvement over the standard U-groove weld, as far as transverse distortion was concerned, so tests were run on mock-up disks. The mock-up disk tests indicated that the distortion was still higher than could be tolerated

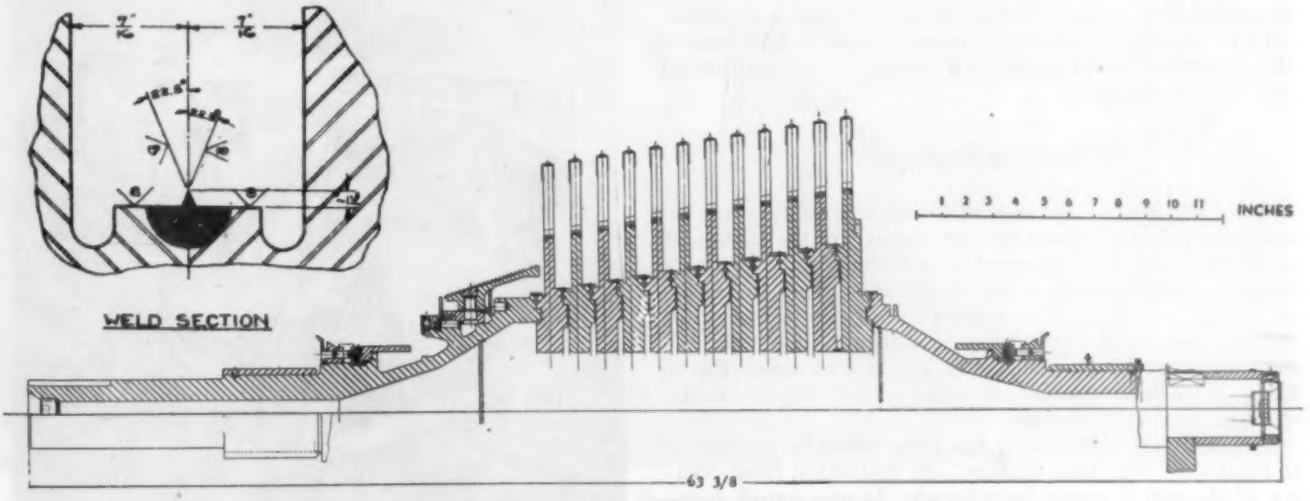


Fig. 1—Section View of Welded Turbine Rotor

* Scheduled for Twenty-Sixth Annual Meeting, A. W. S., October, 1945.
† Manufacturing Division Engineer, Research Dept., Elliott Co., Jeannette, Pa.

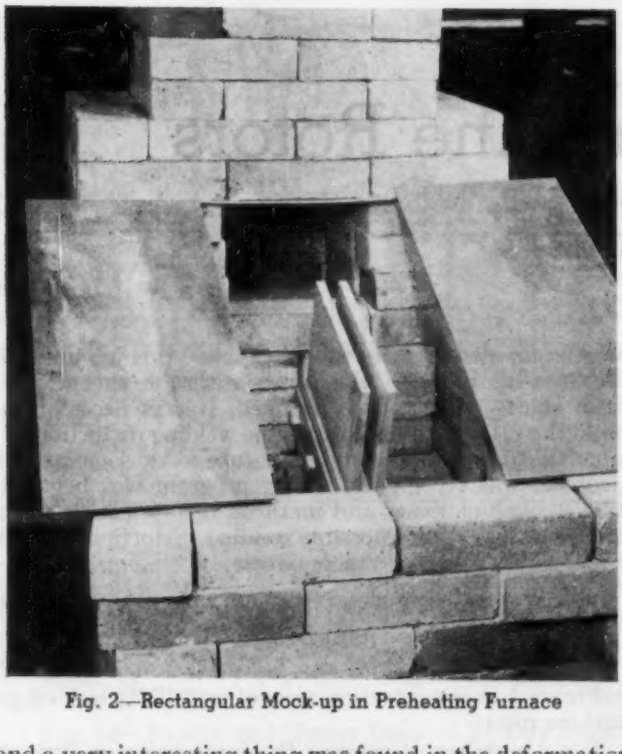


Fig. 2—Rectangular Mock-up in Preheating Furnace

and a very interesting thing was found in the deformation or extrusion of the matching faces directly below the weld. This deformation was felt to be due to the local transmission of heat from the weld to the face directly below it, thereby causing that face to expand locally, and, since the face was rigidly held in compression, material was displaced from the face. In this way, when the welds cooled, the material adjacent the faces was drawn closer together because of the displacement of material from the mating faces. To stop the transmission of heat across the mating faces, a groove was cut directly beneath the weld. This groove acted as a heat dam and prevented extrusion of the matching face below the groove. It was also felt that it helped to make the joint, itself, more flexible and relieved, to some extent, the circumferential stresses developed by longitudinal shrinkage of the weld. Distortion tests made on mock-up disks indicated that the over-all distortion caused by welding this joint was approaching a tolerable amount but was not as yet predictable quantitatively.

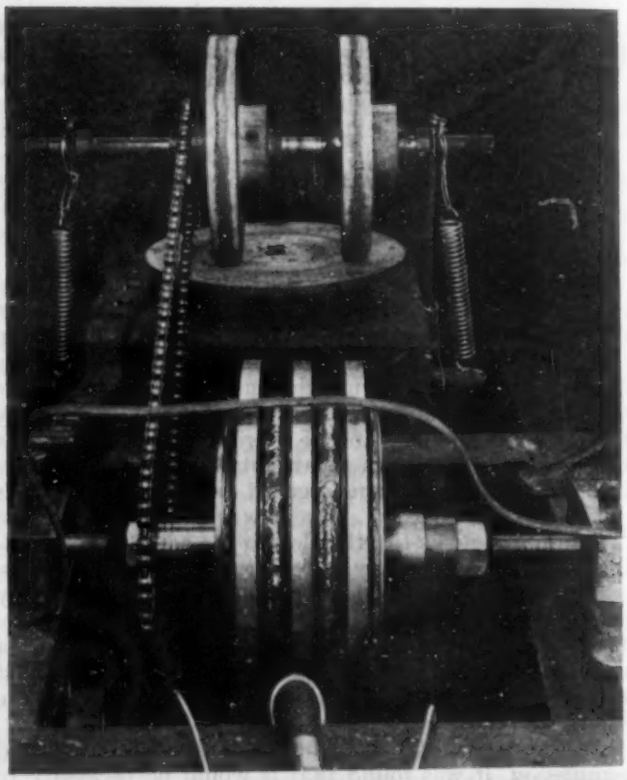
Up to this point, all of the distortion tests had been pointed at a section through the rotor which, while of great importance, did not completely solve the problem of assembling a rotor of many disks. It was now necessary to develop a welding sequence which would control the distortion of the rotor itself, as well as the individual parts of the rotor.

Welding Sequence

Since the disk design was such that the welding was essentially balanced about the neutral axis of the section of each disk and was balanced about the rotor due to its being circumferential, it was reasoned that if the welds were all made at the same instant, the rotor would maintain its shape and would have a uniform and predictable over-all shortening as the only product of weld distortion. This basic philosophy was carried out in all the work on welding sequence.

It was at first felt that if the rotor could be preheated to relatively high temperature, the distortion from cooling of the welds would be reduced. It was found, however, from tests on preheated mock-ups as shown in Fig. 2 that this was impractical from the point of view of manually welding the rotor and had very little effect on distortion in preheat temperatures as high as 800° F. The effect of speed was studied by welding mock-ups shown in Fig. 3 at various welding speeds. In these tests, it was found that the distortion decreased with increased speed but that an arc speed of 10 in. a minute was the most practical on this job. During these tests, mock-up rotors were welded at speeds as high as 23 in. a minute but the reduction of distortion above 10 in. a minute was found to be relatively small so no measures were taken to increase the speed beyond this rate.

Fig. 3—3 Disk Mock-up



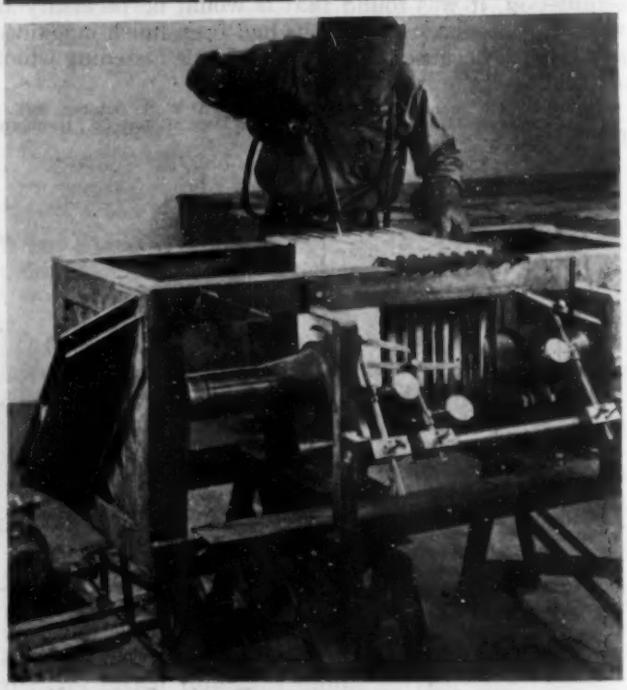


Fig. 4—Welding 9-Disk 19-9WMO Mock-up Rotor

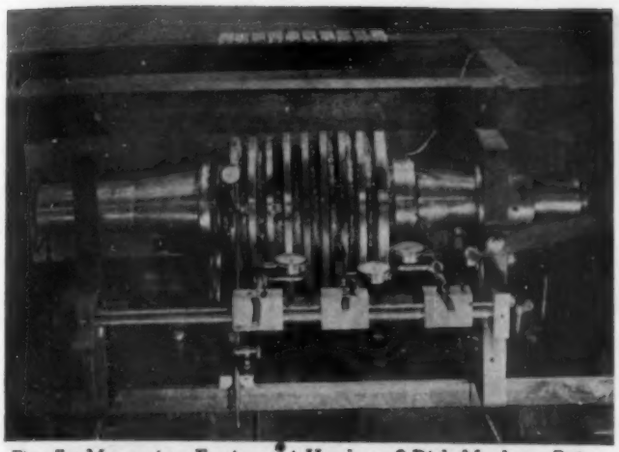


Fig. 5—Measuring Equipment Used on 9-Disk Mock-up Rotor

The nearest approach to making all welds simultaneously and instantaneously was felt to be a distribution of welding in such a way as to achieve this effect. It was decided that the classical method of intermittent backstep welding would be tried and tests were run on various combinations by this method.

Ideally, this distribution of welding would consist of an infinite number of infinitesimal welds. Practically, weld sections of 2-, 4- and 6-in. lengths and two, three and four passes were tried. It was found that 4 in. maximum weld length gave minimum distortion in the weld groove used and that it was necessary to use the intermittent sequence for at least three passes. If the groove were filled with less than three passes distortion was measurably higher than with three or more. The backstep procedure was adopted because it was reasoned to better resist cumulative distortion.

During these tests, it was found that a definite plan to keep the welding as nearly balanced as possible about the rotor and about the neutral axis of each section was essential to the ultimate reduction of distortion and a plan was developed whereby the welding was laid out in small short beads in such a way that the over-all weld unbalance in the rotor was never more than one of these short beads. This plan will be described in detail later.

As a final test of the sequence, a mock-up rotor, Figs. 4 and 5, was assembled and welded.

Welding Procedure

The location of the welding groove in the rotor made somewhat of a problem as far as welding procedure was concerned. In the high-pressure rotor, the disks themselves, were $^{7}/_{8}$ in. apart. There was a distance of at least $6^{3}/_{4}$ in. from the welding groove to the shroud at the end of the blade. The shrouds narrowed the width of the groove at the outside to a maximum of $^{11}/_{16}$ in. In that all parts were finished, it was necessary to carry guards between the rotor disks which further reduced the width of the groove in which it was necessary to weld, so that welding was finally done in a groove approximately $^{1}/_{2}$ in wide and from 9 to 11 in. deep. In order that the operator could see his work in such a welding groove, it was necessary to develop a special electrode holder which, though extremely simple, was absolutely necessary to this job. This holder consisted of a flat piece of steel $^{1}/_{8}$ in. thick and 1 in. wide and approximately 1 ft. long, with an adjustable handle attached. The electrode was welded to the end of this strip which made a very adequate electrode holder.

In the welding mock-ups, it developed that it was not possible to carry a normal arc at the bottom of a groove

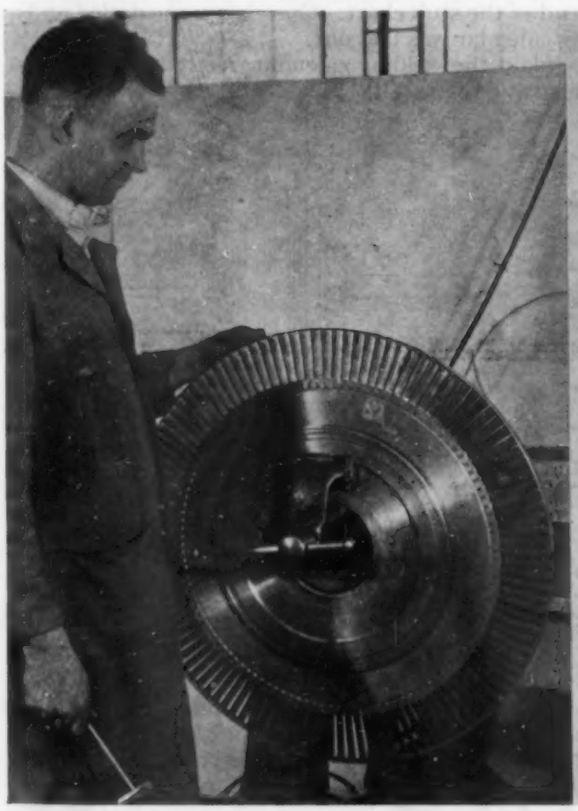


Fig. 6—Rotor Disk Inspection Just Prior to Assembly

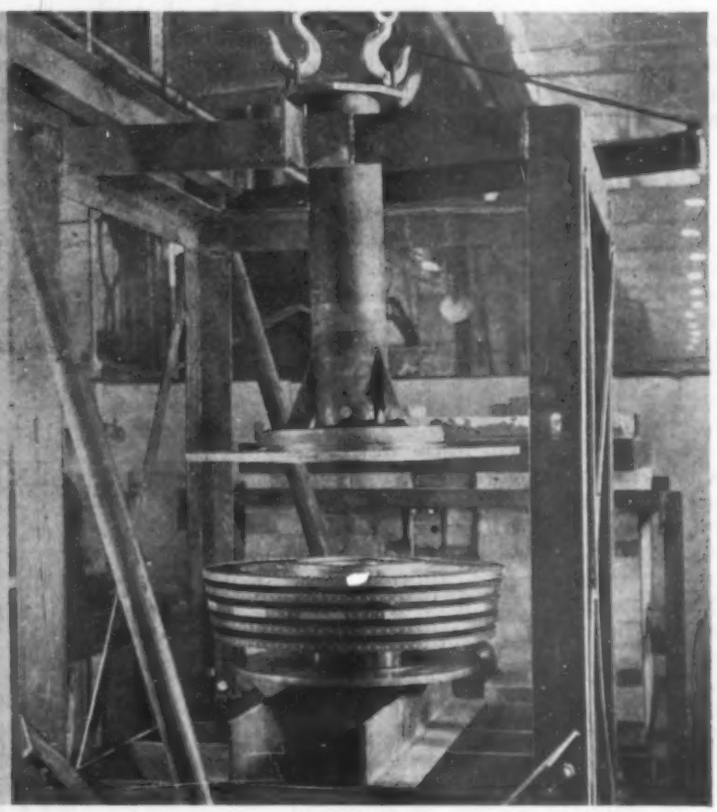


Fig. 7—Rotor Disk Being Lowered Into Position in Assembly Frame

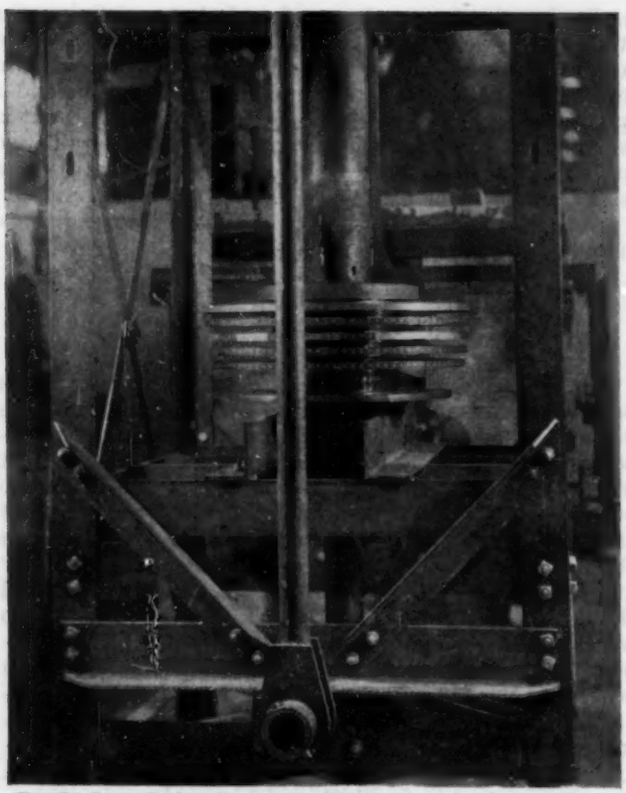


Fig. 8—Rotor Disk in Position and Under Pressure During Cooling of Shrink Fits

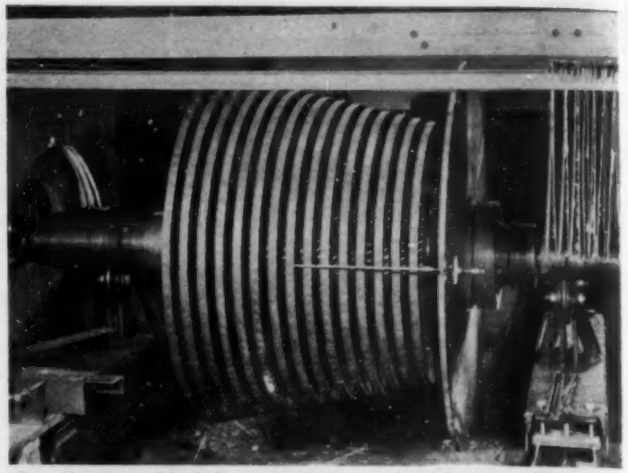


Fig. 9—Assembled Rotor in Position for Welding, Showing Indicating Disk Used in Measurement of Distortion

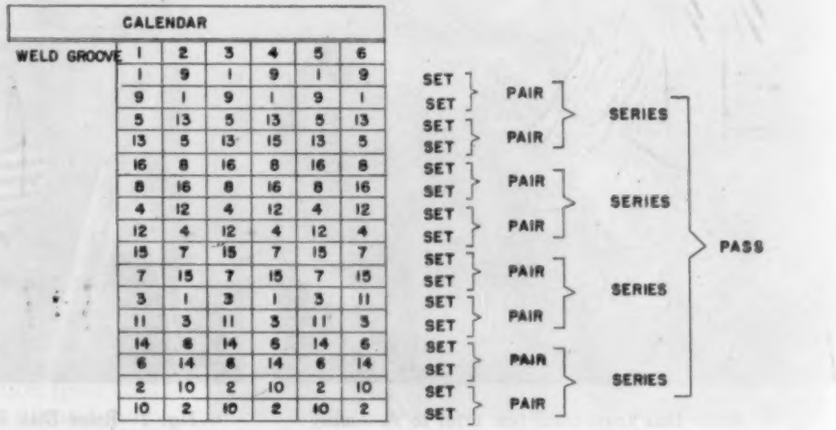
so deep, so unusually high currents were used and the electrode was dragged in the groove. It was found that because of the short duration of each weld, currents in the order of 135 amp. could be used on $^1/_8$-in. electrodes and 180 amp. on $^5/_{32}$-in. electrodes which are rather high current ratings for high-alloy electrode. The electrode which had been developed for the job had unusual operating characteristics for high-alloy material and did a very good job of welding at these high currents and without arc manipulation.

Assembly of Rotors

I believe I have achieved the object of this paper, that is, a demonstration of utilization of classical methods in a new and difficult welding application. However, you will no doubt be interested in the final adoption of these methods to the assembly of gas turbine rotors.

A crate-like framework was built which would support the inlet stub shaft of the rotor. A bladed disk, Fig. 6, was attached to a special bolting fixture and was heated in hot water to a temperature of approximately 200° F. and this hot disk was placed on the stub shaft and cooled so that it would shrink in place as illustrated in Fig. 7. During the cooling, a yoke attached to the frame was swung in place and pressure was exerted to squeeze the stub shaft and the disk together so that the mating faces would be in intimate contact as shown in Fig. 8. This process was carried out with each disk in the rotor until finally the exhaust end stub shaft had been shrunk in place. With pressure on the whole rotor, a guard was inserted in the first welding groove and four tack welds were made at 90° intervals around this groove. Each welding groove was tack welded in this manner, keeping all tack welds in line and using the same sequence on each welding groove. When tack welding was completed, centers were inserted in the ends of the framework to support the rotor by center plugs at each end of the shaft. With the rotor supported on centers, the framework supporting the inlet end stub shaft was removed and rollers were inserted in the sides of the frame to support the rotor on the journal surfaces. At this point, the whole frame, rotor and all, as seen in Fig. 9, was laid over in a horizontal position. A pulley was attached to one end of the stub shaft to be driven by a variable speed drive and an indicator disk attached to the other end of the stub chart. Guards were installed and a welding calendar was laid out.

To explain the welding calendar, reference is made to the illustration, Fig. 10. The rotor is divided angu-



CALENDAR

WELD GROOVE	1	2	3	4	5	6	
	1	9	1	9	1	9	SET
	9	1	9	1	9	1	SET
	5	13	5	13	5	13	SET
	13	5	13	15	13	5	SET
	16	8	16	8	16	8	SET
	8	16	8	16	8	16	SET
	4	12	4	12	4	12	SET
	12	4	12	4	12	4	SET
	15	7	15	7	15	7	SET
	7	15	7	15	7	15	SET
	3	1	3	1	3	11	SET
	11	3	11	3	11	3	SET
	14	6	14	6	14	6	SET
	6	14	6	14	6	14	SET
	2	10	2	10	2	10	SET
	10	2	10	2	10	2	SET

PAIR, SERIES, PASS

Fig. 10

Fig. 11—Welding of Rotor

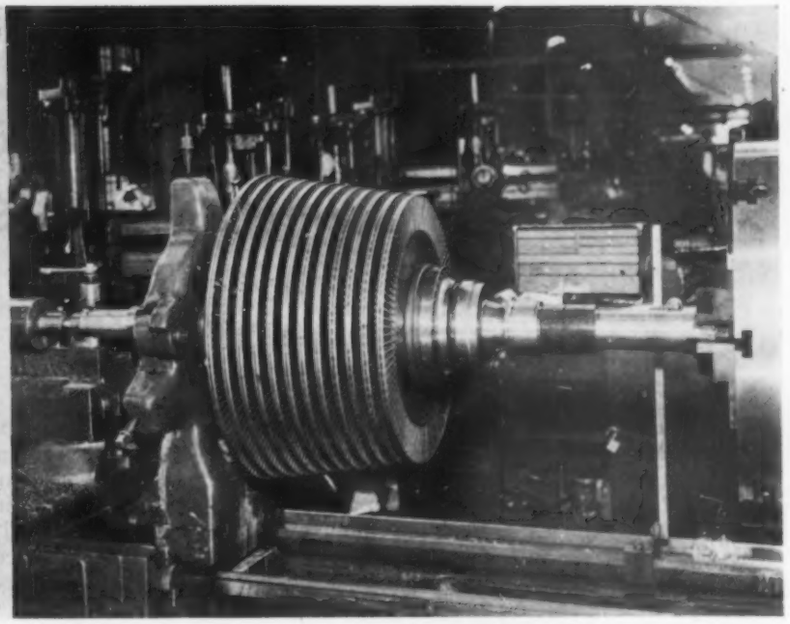


Fig. 12—Finished Rotor

larly into a number of sections and each weld groove is numbered. Welds are laid out in consecutive grooves diametrically opposed so that a balance is maintained in distortion. When a pair is completed the only measurable distortion is a slight shortening of the rotor. The second pair is laid out at right angles to the first and the third pair adjacent to and ending in the first. The sequence is thus completely laid out in the calendar before any welding is done and all welding is carried out strictly in accordance with this sequence.

Welding on these rotors seen in Fig. 11 was carried out on a 24-hr.-a-day schedule in order to meet fast deliveries required on the machine. It was found that in spite of the constant welding, the temperature of the rotor was not increased measurably above room temperature by the welding operation.

The finished rotor is shown in Fig. 12.

The over-all distortion in the two rotors welded by the method described herein was in the order of 0.0025 in. per weld and there was no measurable dishing of any disks in either rotor.

Conclusion

This paper was written in the hope of encouraging further study and application of some of our well-known and classical welding techniques to new fabrications which have hitherto been passed by because of the complication introduced by welding distortion. In spite of its apparent cost, this job has proved itself economically and I believe there are a large number of other welding applications which will require similar study but which will also be economically justified when the job is completed.

(*Continued from page 222*)

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Conversion of a Portable Crane to Welded Design

By F. W. Kessler*

FOR many years cast-iron construction was considered satisfactory for this portable crane, manufactured by The Hill Acme Co., Cleveland, Ohio (see Fig. 1). Having a welding department, the company's engineers became welding-minded. It became clear that this portable crane, one of several of their products, was a natural application for welded design to gain important operating advantages, foremost of which being reduction of dead weight. By the proper use of the simplicity, flexibility and rigidity of welded tubular construction, the engineers cut the weight of the model shown 1225 lb. This saving in weight makes it possible for a girl to move the crane, where formerly it required two or three men. The welded crane is shown in Fig. 2.

* Welding Engineer, The Lincoln Electric Co.

Thinking in terms of welded design for the main parts —the frame and base—the engineers soon discovered other elements that could be improved by welding. For the hoisting mechanism they developed a self-locking worm and wheel which worked much easier, enabling a 60-lb. force, applied to an 18-in. radius crank, to lift 6000 lb. on the hook. Other features are discussed later.

Frame

After a preliminary study, it was decided that commercial pipe would provide the most efficient design from the standpoint of stress-weight ratio and rigidity. It was not only a highly practical application of standard

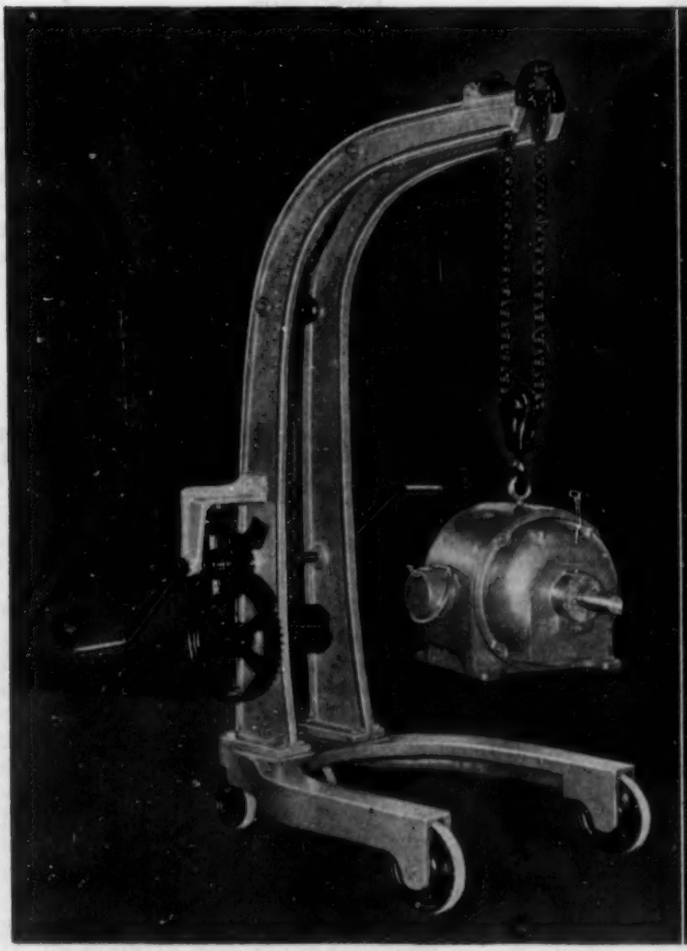


Fig. 1—Portable Crane of Former Cast-Iron Construction. Capacity, 6000 Lb. Weight, 2225 Lb.

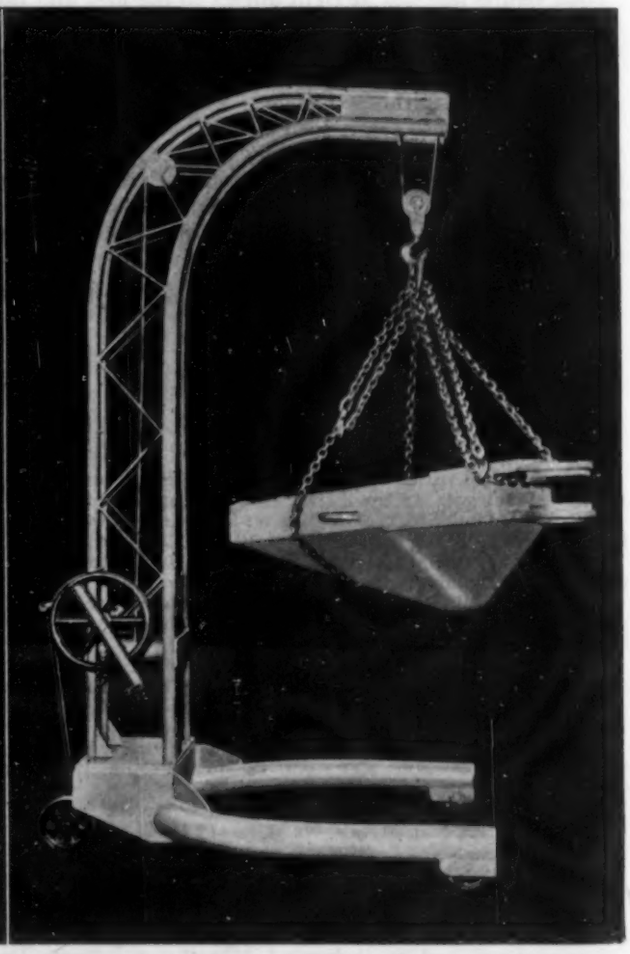
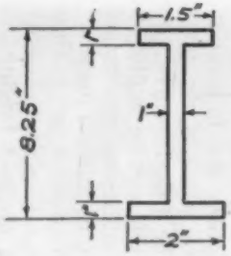


Fig. 2—The Welded Design. Capacity, 6000 Lb. Weight, Only 1000 Lb.—1225 Lb. Lighter Than Former Design



SECTION THROUGH ARM OF CAST IRON CRANE AT POINT OF MAXIMUM STRESS

I = 67 IN⁴ } x 2
AREA = 9.75 IN² }

FIG. 3

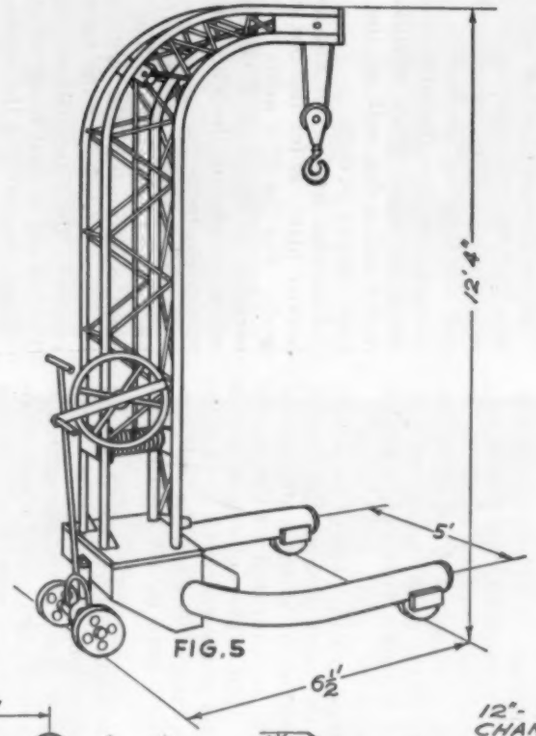
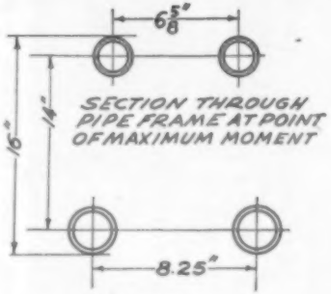


FIG. 5



SECTION THROUGH PIPE FRAME AT POINT OF MAXIMUM MOMENT

FIG. 4

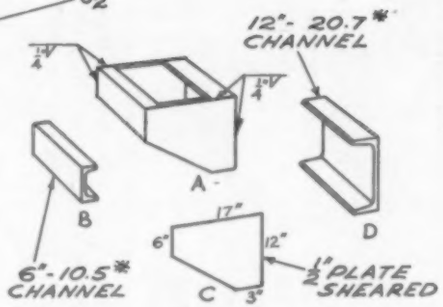


FIG. 10

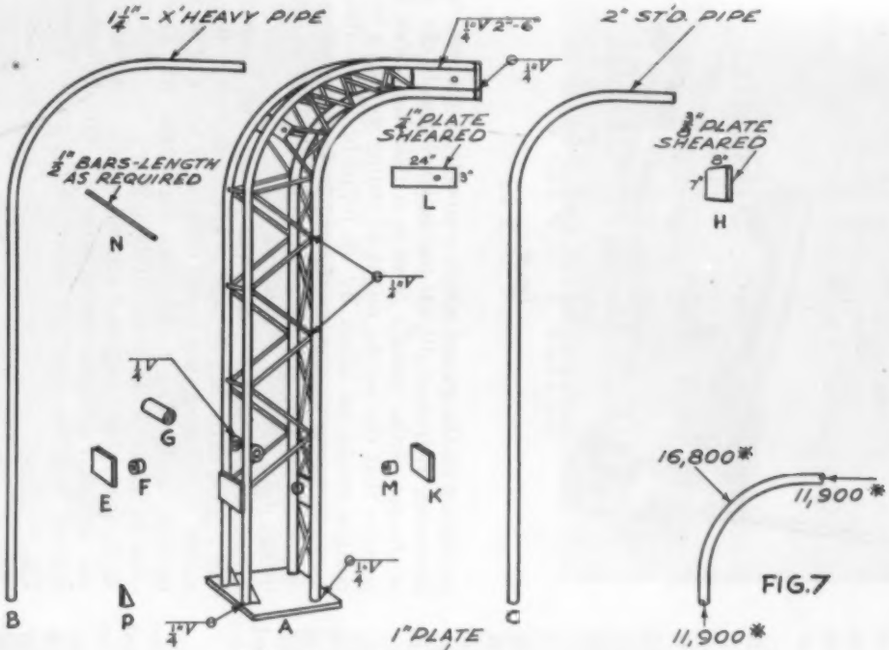
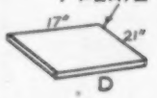


FIG. 6

FIG. 7



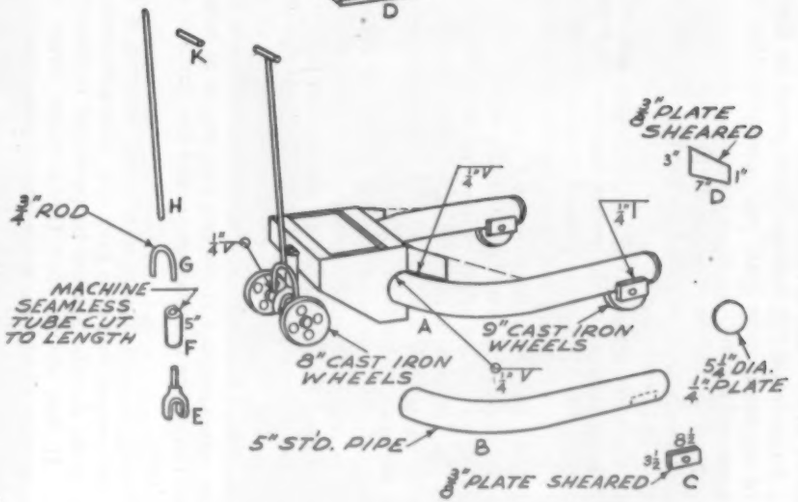


FIG. 9

material, but it resulted in a product of very pleasing appearance.

Figure 3 shows a cross section of one of the arms of the former cast-iron model. The section had a moment of inertia of 67 in.^{4} and a cross-section area of 9.75 sq. in. For a 3-ton crane this resulted in a stress on the tension side of approximately 8000 psi. (assuming that the arm was a curved beam).

Figure 4 shows the section of the pipe frame at the point of maximum bending moment. Tensile stress in this case is 15,000 psi.

For the cast-iron section, the flanges are relatively small in proportion to the entire mass so that the metal which is highly stressed is a small percentage of the total.

In the pipe design, the stress at the outside is 15,000 psi. and on the inner edge of the $1^1/_4$-in. pipe it is 12,000 psi., which gives an average over the whole cross section of 13,500 psi. This appears low, but it must be remembered that there is a possibility of shock loading. Also, the vertical part of the frame may be subjected to impact from swinging of parts being handled.

Over-all dimensions of the welded crane are shown in Fig. 5. Component parts are shown in Figs. 6, 7 and 8.

It is found that the highest stress point is in the horizontal portion at the junction of the pipe and the plate shown in Fig. 6 (*a*). The moment of inertia of this section is 26 in.^{4}, which gives a stress of 15,000 psi.—a much better stress ratio. However, the material being lifted would not strike this section to add the stress of accidental blows.

Having decided on the economical spacing of the pipe and the proper value to give the allowable stress, sufficient cross members must be provided to create a rigid unit. It was shown that the average stress over the cross section of $1^1/_4$-in. extra heavy pipe was 13,500 psi. which gives an unbalanced force to be resisted by shear of 13,500 × 0.88 or 11,900 lb. per pipe. Assuming an allowable stress in shear of 14,000 psi. and a fillet leg length of $^1/_4$ in. for the weld, the length will be: $11{,}900 = L \times {}^1/_4 \times 0.707 \times 14{,}000$ or $L = (11{,}900 \times 4) \div (0.707 \times 14{,}000)$ or approximately 5 in.

This stress of 11,900 lb. will act on a curved section as shown in Fig. 7 so that the cross braces must have sufficient cross section to resist the resultant 16,800 lb. in direct compression and as a column. If the allowable stress is chosen as 18,000 psi. the cross section must be 0.9 sq. in. or five $^1/_2$-in. rods having a cross-section area of approximately 0.2 sq. in. each.

If a $^1/_4$-in. fillet weld is used to attach two of these rods side by side to the pipe, the cross section of this weld would be approximately 0.56 sq. in. giving a strength of 0.56 × 14,000 or 7840 lb. as compared to the tensile strength of two rods of 7200. The column action is small—the slenderness ratio of the rod is 16 divided by $^1/_8$ or 128—or an effective ratio of 64 since the weld can be regarded as causing these bars to act as fixed end columns.

The column action of the frame as a whole is also small since the vertical part is 96 in. long for the largest model. The radius of gyration is 3.91 $r^2 = 191$ or approximately 7. Hence, the slenderness ratio is 96 over 7 which is approximately 14. Thus, the vertical portion will act like an eccentrically loaded compression member.

Base

Now consider the members comprising the base or truck, shown in Figs. 8, 9, and 10.

For the 3-ton crane, a 5-in. standard pipe with a gusset, as shown in Fig. 9 (*d*), gives a unit stress of 14,500 psi. in tension in the pipe, and 19,800 psi., in compression

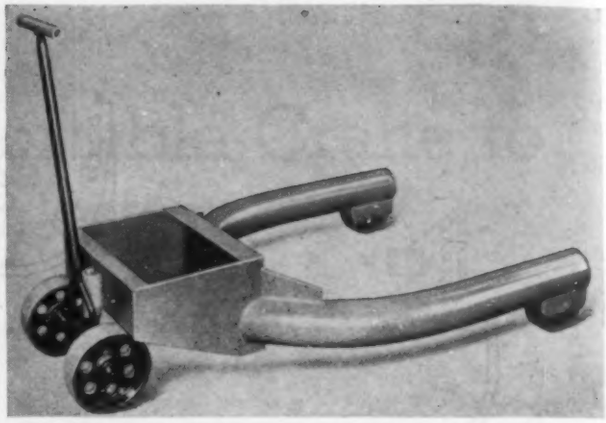


Fig. 8

in the top of the gusset which connects to the base box. However, a stress of 19,800 psi. is developed in the pipe at the toe of the gusset. This is a little high since it is possible that the weight might be swung so that a larger portion would be taken by an individual leg—thus it would be better to increase the width of the gusset at the connection to the base by 1 in., and the length as shown by the dotted line, in Fig. 9 (*a*).

One of the most critical welds is the one connecting the $1^1/_4$-in. extra heavy pipe to the base plate. By moments, it is found that a pull of 9000 lb. must be resisted by this weld. The $^1/_4$-in. fillet leg length will give an area in shear of approximately 0.90 sq. in. while 1.30 sq. in. is necessary, assuming an allowable shear of 14,000 psi. and that a shock load is present. The difference of 0.40 sq. in. is furnished by means of the gusset shown in Fig. 6 (*p*).

Construction

Figure 10 shows the box which uses structural channels to advantage—thus saving several long welds. Natural subassemblies of the crane are the mast, the base or truck and the hoisting mechanism. The hoisting parts are made of castings—the innovation being the use of a single worm and wheel which is self-locking, thus eliminating a rachet and a dog with all the nuisance of operation of these clumsy devices.

Electrodes used.—For the largest fillet weld in the heavier plate, as for the box channels, an E-6020 electrode. For the fillet welds on the mast and the leg connections to the base, E-6012 electrode. For the butt welds, connecting the wheel supports to the base pipes, E-6010 electrode.

The breakdown, as indicated above for fabrication, has several advantages. The base plate of the mast, and the channels of the base can be drilled for assembly by means of bolts, or the mast plate can be welded directly to the base without any additional machinery. The bolting is used where shipping conditions require.

Then, too, 90% of the cranes are manufactured principally to dimensional requirements, rather than capacity. This breakdown allows a variety of mast heights and clearances, the same being true of the base and truck. Hence, a number of sizes can be made economically (no patterns are necessary). To change a model, it is simply necessary to change the length or size of pipe. Thus the manufacturer can supply the customer with a variety of sizes to meet the individual needs at practically no extra cost.

Jigs and fixtures are used in fabrication to the fullest

extent so that the majority of the welding can be in the downhand position. Also the material is prepared so that close tolerances and fit-ups are obtained—the dimensions being to the nearest $^1/_{16}$ in. Very little machining is necessary for the finished weldments since the parts are prepared entirely before being welded in place.

This design also offers a good example of the integrating of forgings, castings and commercial plates and shapes to produce a highly satisfactory product. Study is now being made to determine the feasibility of replacing some of the castings with welded steel—so that eventually the whole crane will be a 100% welded product.

Simple Setup for Small-Lot Flame-Hardening of Valve Plugs

By R. H. Brooks*

THE useful life of plug valves used in oil-refinery equipment depends largely upon their resistance to wear and to thermal shock. A manufacturer

* Service Operator, The Linde Air Products Co.

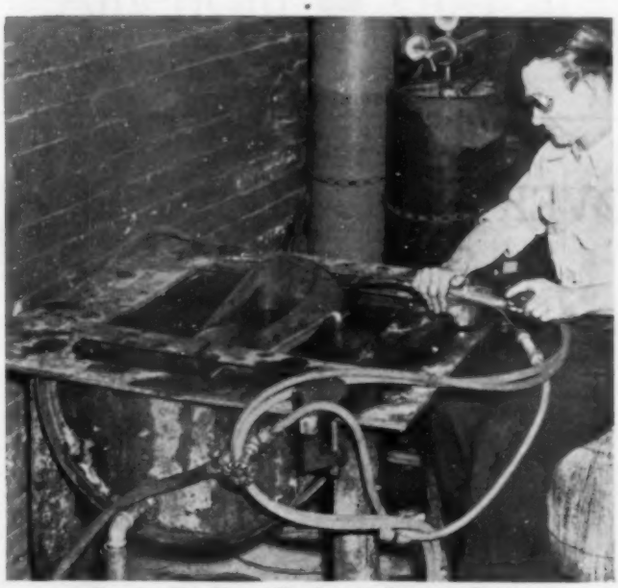


Fig. 1—The Flame-Hardening Setup in Action

A segment of the plug's surface is hardened at one time. Even with this remarkably simple setup there are no soft streaks in the hardened surface of the plugs.

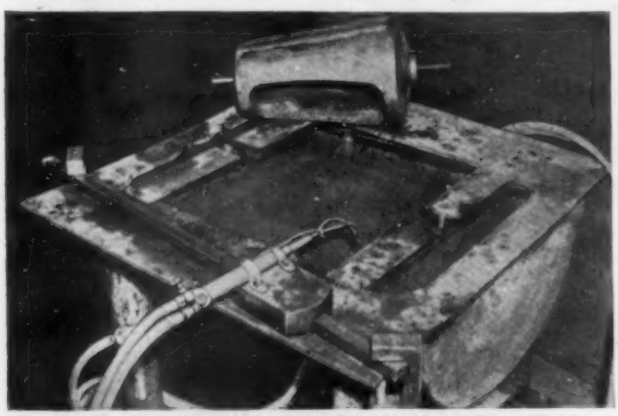


Fig. 2—An Over-All View of the Oxyacetylene Flame-Hardening Setup

The blowpipe is mounted on a grooved block which the operator slides along a square bar clamped to the top of the tank. A partially hardened valve plug is resting on the rear portion of the tank.

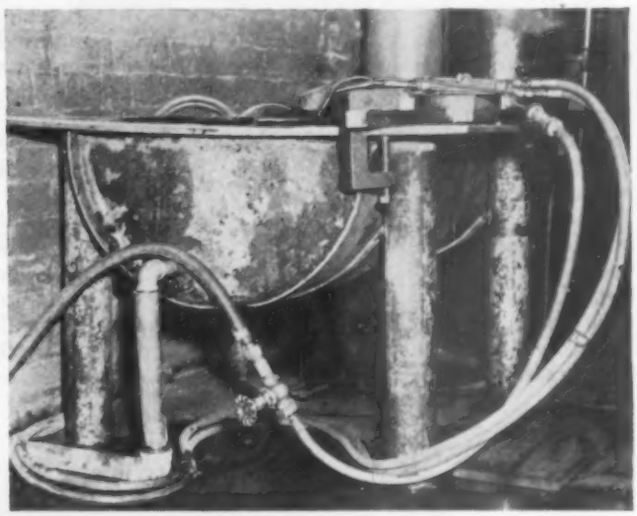


Fig. 3—A Tank, Made from a Steel Drum, Is Used for Collecting the Quench Water

This water bath protects the hardened portion of the work against further heating. Two notched I-beams for holding the work are placed on top of the tank.

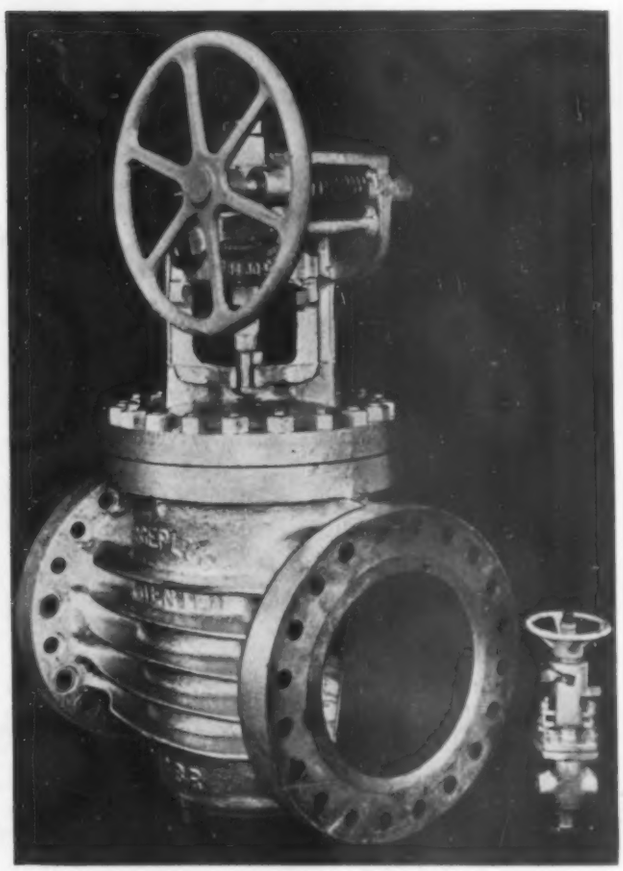


Fig. 4—Two Finished Plug Valves

(Left) A 14-in. size; (right) a 1-in. size. Plugs for all valves within this size range can be flame-hardened easily with the above equipment.

supplying valves for such tough jobs has found that the oxyacetylene flame-hardening process is the best method of obtaining the desired physical surface properties in the plugs used in these valves.

A simple hand-operated jig has been set up for flame-hardening plugs used in valves ranging from 1-in. to 16-in. pipe size. The plugs are made of type G. A. Meehanite, which has a basic hardness of 250 on the Brinell scale. Using the progressive flame-hardening method followed by a water quench, a $^1/_{16}$-in. case with a Brinell hardness of 400 is produced at the rate of approximately 12 in. per minute. Operating conditions such as flame intensity, speed of travel of the heating flame, and type of steel being treated can be varied to produce special hardness and depth.

The use of a mechanized installation was considered but because of the small production capacity of the plant it was felt that the use of such a mass production flame-hardening tool would not be justified in this case. The various sizes of plugs, made in small lot orders, can be very effectively heat treated with the versatile, simple hand-operated setup.

In using the progressive flame-hardening method the operator moves the heating blowpipe laterally along the surface of the plug at a uniform rate of speed. Immediately behind this flame is a stream or spray of water which progressively quenches the heated surface. The direction of movement is guided by a clamped bar which can be adjusted to keep the tip of the blowpipe at a constant distance from the surface of the work. After each pass the work is rotated until the hardened portion is submerged in the protective water bath, and a new segment of its surface is hardened in the same manner.

The entire surface of the plug with the exception of the sharp machined corners of the passageway is hardened and then finished by lapping. Since flame-hardening is accompanied by a minimum of distortion, the plugs can be machined before hardening—a procedure that would have been impossible with the previous method of hardening. This has resulted in substantial savings in machining costs. The accompanying illustrations show the simple equipment used by the Wedgeplug Valve Company for flame-hardening these plugs.

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AO 203CL Short Jacket gives full protection for arms, neck, chest and shoulders.

THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

BY-LAW AMENDMENTS

At the Board of Directors meeting held on February 6, 1946, in Cleveland, Ohio, the following By-Law amendments were approved. In accordance with the established policy of the SOCIETY, these amendments are published in THE WELDING JOURNAL 30 days in advance of their submittal to the voting membership.

ARTICLE IX

Nomination and Election of Officers

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$2000 IN PRIZES FOR PAPERS ON RESISTANCE WELDING

Announcement has been made of cash prizes to be awarded in 1946 by the Resistance Welder Manufacturers' Association for outstanding papers dealing with resistance welding subjects. The total amount of the awards is $2000, and a wide choice in subject matter is allowed in order to assure eligibility to all papers which cover worth-while and significant achievements in the field. The contest judges will be appointed by the AMERICAN WELDING SOCIETY, and awards will be made at the 1946 Fall meeting of the SOCIETY. The prizes and rules governing the contest are as follows:

One prize of $750 for the best paper emanating from an industrial source, consulting engineer, private or government laboratory, or the like, the subject matter of which is concerned specifically with resistance welding. There are no restrictions on the scope of the subject matter. For example, it may be devoted to redesign of a product or products for resistance welding, improvement (from a welding and cost viewpoint) in a present design for resistance welding, resistance welding research, development of new procedures to broaden the field of application of resistance welding, etc. Papers in these categories should explain the economic importance of the accomplishments described in the paper—that is, cost savings, production improvement, scope of application, etc.

A prize of $500 for the second best paper in the above classification. A prize of $250 for the third best paper in the above classification.

A prize of $300 for the paper emanating from a university source—that is, either an instructor, student or research fellow which in the opinion of the Board of Awards is the greatest original contribution to the advancement and use of resistance welding. A prize of $200 for the second best paper emanating from a university source.

The contest is open to anyone, without restriction, from the United States, its possessions and Canada. It is also open to any member of the AMERICAN WELDING SOCIETY in any grade from any place in the world. The contest is considered as having opened August 1, 1945, and will close on midnight, July 31, 1946. Papers which are to be presented at the Annual Meeting of the AMERICAN WELDING SOCIETY in October may also be entered in this contest, in which case a draft or copy of the paper must be filed with the AMERICAN WELDING SOCIETY not later than July 31, 1946.

All papers submitted in the contest become the joint property of the R.W.M.A., and the AMERICAN WELDING SOCIETY, who will retain all rights thereto. The AMERICAN WELDING SOCIETY will appoint five judges, who will judge the relative merits of the various papers submitted and make the awards accordingly. The decision of the judges will be final.

For the author or authors to be eligible for this award, the paper shall describe clearly original work done by them or under their supervision on resistance welding in any of its aspects by any method or process. The paper shall be a full disclosure on the subject. The paper shall contain no statement which is unethical advertising or sales promotion. The paper may contain statements of fact, including the names of either individuals or organizations of any kind, commercial designations, trade names, etc. The minimum length requirement is 2500 words.

All papers must be typewritten, double spacing, written on one side only of blank white paper. Photographs, charts, graphs, etc., may either be attached directly to the copy or may be detached, in which case they should be clearly identified with figure numbers, captions, etc.

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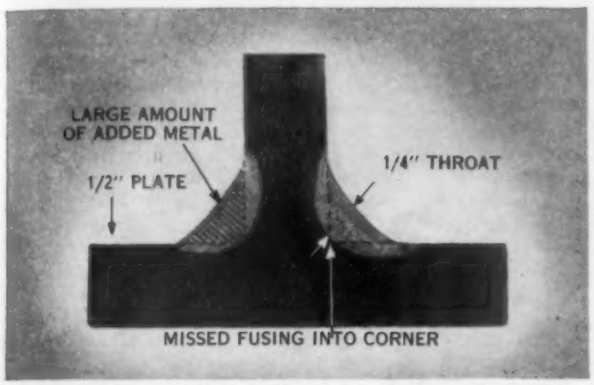
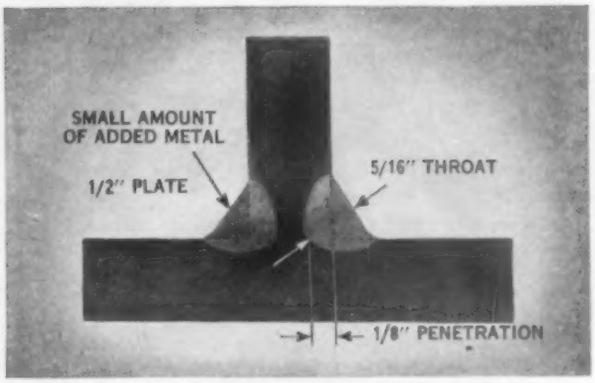


NEWTIME: 12" PER MINUTE



How to weld fillets 140% *faster*

Example: Single pass fillet weld in ½" plate, horizontal position.

1. **Use ¼" "Fleetweld 11" electrode, 350 amps., D. C. (electrode negative) or A. C.**
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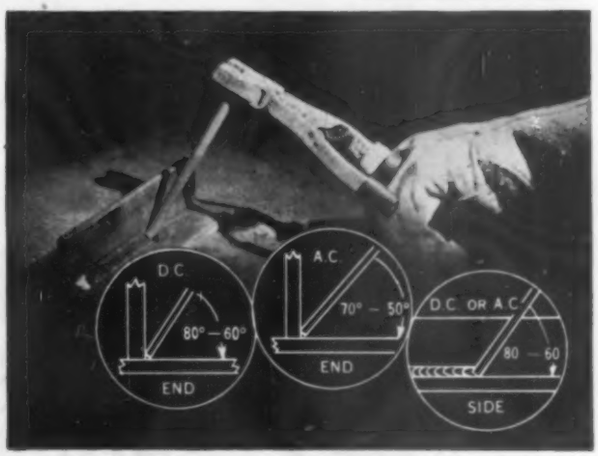

Complete procedures for all types of joints in mild steel given in handy "Fleet-Welding" pocket-size manual, Bul. 444. Free on request. Ask for it on your business letterhead.

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America's greatest natural **recourse**

ARC WELDING

THE AMERICAN WELDING SOCIETY

ACTIVITIES - RELATED EVENTS

BY-LAW AMENDMENTS

At the Board of Directors meeting held on February 6, 1946, in Cleveland, Ohio, the following By-Law amendments were approved. In accordance with the established policy of the SOCIETY, these amendments are published in THE WELDING JOURNAL 30 days in advance of their submittal to the voting membership.

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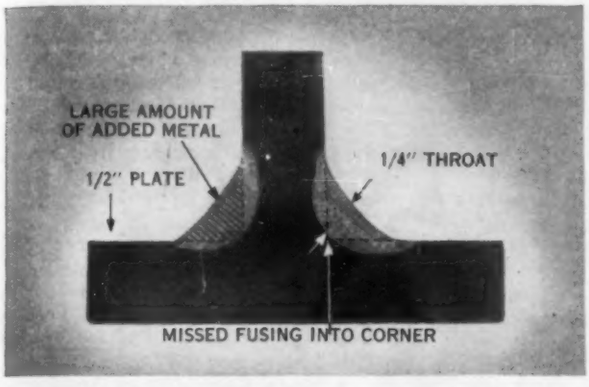

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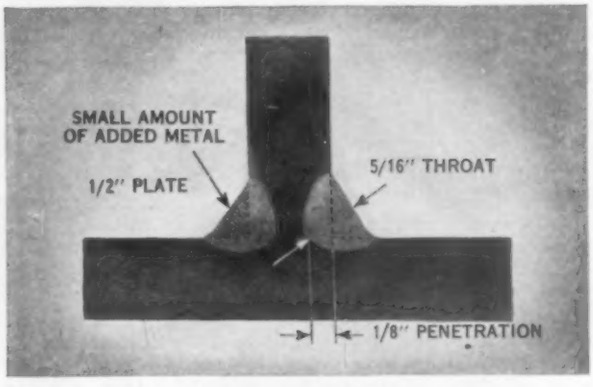

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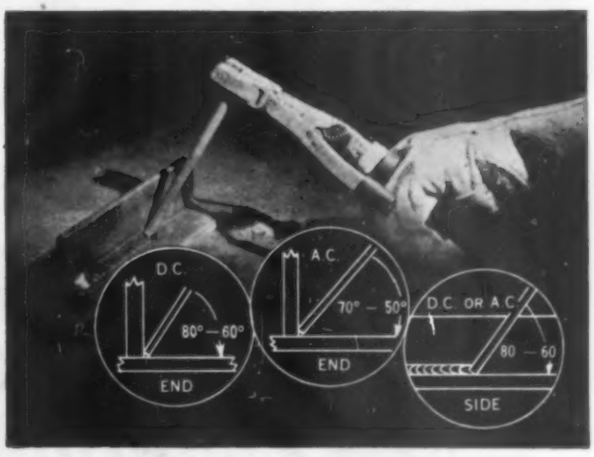

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THE LINCOLN ELECTRIC COMPANY • DEPT. P-1 • CLEVELAND 1, OHIO

America's greatest natural **recourse**

ARC WELDING

SUSTAINING MEMBER

National Cylinder Gas Company, 4950 Santa Fe Ave., Los Angeles 11, Calif., is a nation-wide producer of industrial gases as well as electric welding equipment and oxyacetylene welding and cutting apparatus. Seventy-three plants and several hundred distributing warehouses are strategically located throughout the United States.

Among National products are oxygen and nitrogen; hydrogen, acetylene and other fuel gases; carbon dioxide; Rego and Torchweld oxyacetylene apparatus, Torchweld acetylene generators, National shape-cutting machines; Hollup arc welders and Sureweld electrodes, and welding accessories.

ARC WELDING INSPECTION HANDBOOK

The AMERICAN WELDING SOCIETY has recently published a new book entitled *Inspection Handbook for Manual Metal-Arc Welding*. This 156-page handbook is the most complete and authoritative manual that has yet been published on the subject of welding inspection. It covers requirements for a welding inspector, duties of a welding inspector, methods of testing welds and a comprehensive description of weld inspection by visual, magnetic-particle and radiographic methods. One section of the Handbook discusses the principal types of weld defects and indicates how they may be detected and corrected. The entire book is written in simple language and is intended to serve as a reliable source of information on any welding inspection problem.

This Handbook was prepared by the A.W.S. Army Ordnance Advisory Committee, at the request of the Ordnance Department of the U. S. Army. It was first published by the Ordnance Department late in 1944, under the title *Ordnance Inspection Handbook for Manual Metal-Arc Welding*, and was widely used as a manual for ordnance inspectors. The present A.W.S. version embodies a number of editorial changes designed to clarify the text and correct several errors that were present in the original publication.

Copies of the *Inspection Handbook for Manual Metal-Arc Welding* may be obtained from the AMERICAN WELDING SOCIETY, 33 West 39th St., New York 18, N. Y., at $1.50 per copy.

1946 A.S.T.M. ANNUAL MEETING IN BUFFALO, JUNE 24–28, 1946

Several interesting technical symposiums are being prepared for the 1946 Annual Meeting of the American Society for Testing Materials to be held at the Hotel Statler in Buffalo during the week of June 24th. Also under way at this time will be the Seventh A.S.T.M. Exhibit of Testing Apparatus and Related Equipment and the Annual Photographic Exhibit. In addition to the some 15 to 20 technical sessions necessary for the program there will be a large number of meetings of the Society's technical committees.

Two of the symposiums which should be of much interest will involve Testing of Parts and Assemblies; the second, covering Fatigue of Materials. The Society for Experimental Stress Analysis is joining with A.S.T.M. in sponsoring the symposium on Testing of Parts and Assemblies.

Further topics will include round table discussion on Test Methods of Freezing and Thawing Concrete to Determine Durability, a session dealing with Tools for Identification of Water-Formed Deposits and a Symposium on pH Measurement.

The Annual Edgar Marburg Lecture, always an outstanding feature of the meeting, will be presented this year by Dr. J. J. Mattiello, Technical Director of the Hilo-Varnish Corp., on the subject "Protective Organic Coatings as Engineering Materials."

A general Committee on Arrangements of A.S.T.M. Members in the Buffalo District is planning a number of special features for the meeting under the chairmanship of B. L. McCarthy, Wickwire Spencer Steel Co., with T. L. Mayer, Head, Buffalo Technical Library, *Secretary*.

● If the cost of carbide per 100 lb. drum is $5.10, the cost of the Sight Feed Acetylene per 100 cubic feet is $1.07. Compare this with the price you are now paying for acetylene.

Sight Feed keeps you from running out of acetylene and losing heat in the middle of a job —you see the carbide charge in the hopper and you know you have enough before you start.

Contact your jobber or write—

ACETYLENE Sight Feed GENERATORS

THE SIGHT FEED GENERATOR COMPANY

RICHMOND, INDIANA

EASY-FLO brazing—

Photo courtesy of Edwin L. Wiegand Co. Pittsburgh, Pa.

At right, above, you see the formed, tubes, flanges and rings of EASY-FLO wire. Operator slips EASY-FLO rings on tube ends, inserts ends in flange, places assembly in fixture and applies Handy Flux. While she does this another assembly in the induction coil (center) is brazed. At left is a third fixture with finished assembly. With the three fixtures she turns out a steady stream of reliably brazed heaters.

The fast, low-cost way to make WATER-TIGHT joints

For making water-tight metal joints on a commercial basis, brazing with the low-temperature silver alloy EASY-FLO is your answer on a wide range of jobs. And here are the two main reasons why:

1.—EASY-FLO brazing consistently makes joints that are just as water-tight and just as strong and lasting as solid metal.

2.—EASY-FLO brazing lends itself readily to simple production methods through which *ordinary labor* can reliably turn out these strong, water-tight joints at *fast rates*—all of which assures *low costs.*

One good example comes from the Edwin L. Wiegand Co. of Pittsburgh—the EASY-FLO brazing of their widely used CHROMALOX Immersion Heaters. Wiegand engineers worked out the simple procedure illustrated, for brazing the formed copper tubes to the copper-clad steel flanges which produces the required 100% water-tight joints with speed, reliability and economy.

GET FULL EASY-FLO FACTS IN BULLETIN 12-A

It explains exactly what this alloy does and why. Also tells you where and how you can profitably put EASY-FLO to work on your own metal joining. Write for a copy today.

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$4,500,000,000 BUSINESS PREDICTED FOR AGE OF ELECTRICAL LIVING

The modern age of electrical living now dawning in American homes will provide jobs for more than 600,000 men and women and will mean an annual business of $4,500,000,000 during the next five years, B. W. Clark, vice-president in charge of sales for the Westinghouse Electric Corp., forecast in New York City recently.

Mr. Clark spoke to metropolitan newspaper and magazine editors at a preview of 1946 Westinghouse home consumer products at the Waldorf-Astoria.

The theme of the preview was set by a color film "The Dawn of Electrical Living," prepared by the Walt Disney Studios in Hollywood for Westinghouse as the Co.'s contribution to the industry program to inform the public of the importance of adequate wiring in new and old homes.

Employment Opportunities Analyzed

Mr. Clark conservatively estimated that 150,000 will be employed in the making of home appliances and radios; 125,000 in producing generating and distribution equipment required to bring electricity to the nation's homes; 80,000 in the maintenance, installation and operation of electric utilities; 30,000 in the wiring and rewiring of homes, and 250,000 in the distribution and sales of appliances.

"It is generally agreed that we need, within the next 10 years, 7 to 10 million housing units of all kinds.

"The business of electrical living starts with buildings, because concealed within the walls must be the wires, switches and protective devices to provide current for lighting fixtures and appliances. At a probable average cost of $160 per home, this preliminary new house wiring should amount to a volume in materials, labor and other costs of upwards of $65,000,000 per year."

Summarizes Trend Toward Electrical Living

In summarizing the increased trend toward electrical living, Mr. Clark said, "Today we buy an electric refrigerator for half the money we would have spent for it 10 years ago. We buy a unit of electric energy to perform so many of our ordinary daily tasks for half the money. While this has been happening, all wages have been going up. So has almost everything else. But real wages—the things they will buy in electrical living—have truly skyrocketed."

ELECTRODE BULLETIN

The Hobart Brothers Co., Troy, Ohio, has just released a strip folder announcing their complete, postwar line of arc welding electrodes. This handy pocket size folder furnishes description, application, procedure, physical properties of deposited metal and sizes available for each type electrode in this new postwar line. You can obtain a copy of this handy folder by writing direct to The Hobart Brothers Co., Troy, Ohio. Request Folder DM-710.

NEW BOOK ON STRESS-CORROSION CRACKING

Metallurgists and many other scientists and engineers concerned with corrosion will be interested to know that the papers and discussions given at the joint A.S.T.M.-A.I.M.E. symposium on stress-corrosion cracking held in Philadelphia in November 1944 are now available in bound form. This volume, the first to bring together present-day knowledge and recently determined data on the failure of metals and alloys under conditions of combined stress and corrosion has been edited by Carter S. Cole of the A.S.T.M. staff.

Stress-corrosion cracking has been the subject of research and speculation for three decades. It is a phenomenon of major engineering significance and of considerable theoretical interest and many puzzling and apparently contradictory facts have been uncovered and the theories advanced to explain the phenomenon have been varied and frequently conflicting.

National
Carbide
IN THE RED DRUM
EFFICIENT
ECONOMICAL
DEPENDABLE

FOR WELDING and CUTTING
Use National Carbide in the Red Drum
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CHIPPING GOGGLES
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WELDING MACHINES: A. C. TRANSFORMER TYPES
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WELDING GOGGLES
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WELDING CLEANING TOOLS
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WELDING CLAMPS
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SAFETY CLOTHING
•
WELDING GLOVES
•
CARBON PASTE & FLUXES
•
WELDING CABLE CONNECTORS
•
WELDING CARBONS
•
CARBON PLATES
•
WELDING CABLE
•
WELD SPATTER ELIMINATOR
•
ELECTRODE HOLDERS

• For the deposition of exceedingly sound, clean weld metal when welding in sharp, narrow grooves of heavy plate thickness, use **CHAMPION Black Devil Electrodes.** The **Black Devil** is recommended for high speed welding in the flat position and for making 45° horizontal fillet welds that are extremely smooth and slightly concave in appearance.

Whatever **your** particular welding problem, there is a **CHAMPION Welding Electrode** which will provide superior welds and increased production. The name of **CHAMPION** guarantees the result.

THE CHAMPION RIVET COMPANY

CLEVELAND, OHIO — **EAST CHICAGO, IND.**

The whole field of stress-corrosion cracking was thoroughly covered at the three-day meeting; there were papers on the theory of stress-corrosion cracking, on test methods, on the failure of brass and other copper-base alloys, on the testing and susceptibility to failure of the light alloys, and on stainless steel, galvanized steel, bridge wire, and a series of other materials including nickel and nickel alloys, lead alloys and low-carat gold.

The volume containing these papers and discussions is printed on a prewar high-grade paper and is substantially bound in blue cloth. It will be sold to members of the two cooperating societies at $5 for one copy, and to nonmembers for $7.50. Members of the Institute of Metals and the Iron and Steel Institute of Great Britain may purchase copies for $5.50 each. All of the books will be sold through the A.I.M.E.

AMPCO PRODUCTS AND SERVICES

Ampco Metal, Inc., Milwaukee 4, Wis., has issued Bulletin 72, highlighting the Ampco line of alloys, specialties and services.

For many years Ampco has been nationally known for its sand and centrifugal castings, but some were not familiar with additional products and services which have been developed recently. The new bulletin discloses that the activities of the company have been broadened so that today it offers many specialties, such as resistance welding electrodes, mill products, continuous cast bearing bronzes, Ampco clad metals, pumps and fabricated assemblies. The lines of nonsparking safety tools and arc welding electrodes have been enlarged. Facilities for precision machining, which were emphasized during the war when the company finish machined aircraft parts to extremely close tolerances, are also maintained and this service continues as an important facility.

Copies of Bulletin 72 will be sent on request to Ampco Metal, Inc., Milwaukee 4, Wis.

R. G. ALISON APPOINTED SALES MANAGER

The appointment of R. G. Alison as sales manager of the welding division has been announced by M. N. Vuchnich, general manager of the Lincoln Electric Co. of Canada Ltd., producers of arc welding equipment and electric motors.

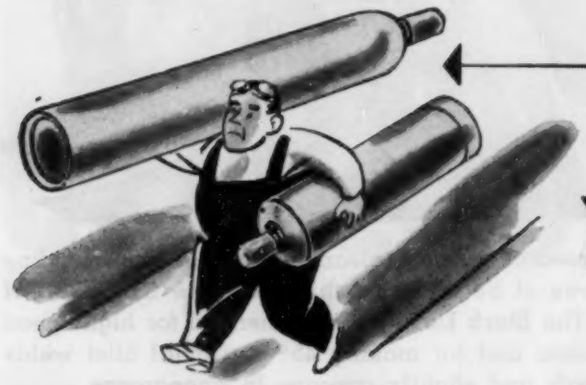
Mr. Alison has been with the company for the past 9 years. Born in Toronto, Ont., in 1912, he obtained his college education at the University of Toronto, where he received a degree in mechanical engineering.

Following graduation, Mr. Alison received his training in arc welding at The Lincoln Electric Co., Cleveland, Ohio. Upon his return to Canada he was selected as Lincoln representative for the Western Provinces. Later he was transferred to the Toronto Office as a specialist in the design of welded products. He was later appointed as District Manager of the firm's Windsor Office, continuing at this point until his transfer to the Head Office.

Mr. Alison has had a wide experience in arc welding. He has contributed numerous technical articles to trade magazines and frequently lectures to schools and technical societies. During the war, he was employed for a time by the Department of National Defence as a welding adviser to the Royal Canadian Ordnance Corps in England. He also assisted the Department of Munitions and Supply in conducting investigation on flame-hardening of armor plate.

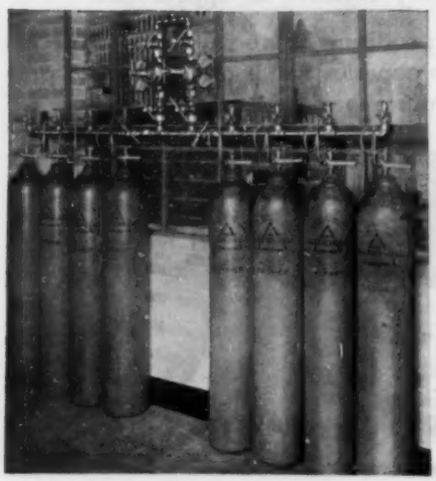
He is a member of the Association of Professional Engineers of the Province of Ontario, AMERICAN WELDING SOCIETY and the Canadian Welding Society.

R. G. Alison



What

DOES IT COST YOU TO HANDLE CYLINDERS?



• Every pair of cylinders that "run-out" in your shop increases your overhead—because the time needed to get full cylinders . . . to switch regulators . . . and to make pressure and flame adjustments is *not* productive.

You can eliminate all excessive cylinder handling costs with a RegO manifold . . . and get other advantages too! Write for full details now.

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Pioneers and Leaders in Equipment for Using and Controlling High Pressure Gases

ENDURANCE INSURANCE

Weld Inspection by G-E X-Ray

Maybe demands still exceed your production capacity . . . Maybe they will for some time to come . . . Maybe.

But keener competition lies ahead. That means a greater-than-ever accent on quality. To meet this challenge, forward-looking users of welding are relying on radiography . . . mandatory or not. By insuring quality through x-ray inspection—G-E X-Ray in a majority of cases — they minimize the "maybe" in their postwar future.

Rapidly and non-destructively, x-ray provides proof of a weld well-done . . . Positive proof, because even minute defects have no concealment when welds are radiographically tested. Proper x-ray equipment enables you to handle any job better—serves as a guide to better technics—is an expediter, teacher, cost-cutter and prestige protector. And in the complete line of rugged, highly precise G-E X-Ray Industrial Units is proper equipment for *your* particular requirements.

Now is the time to plan for x-ray . . . and our staff of experienced x-ray engineers is ready and anxious to help you. Write or wire to General Electric X-Ray Corporation, 175 West Jackson Blvd., Chicago 4, Illinois, Dept. 2524.

GENERAL ELECTRIC X-RAY CORPORATION

HOW TO CUT CAST IRON

The Technical Service Dept. of National Cylinder Gas Co., 205 W. Wacker Drive, Chicago 6, Ill., has just issued an illustrated circular completely covering the "how to" on the cutting of cast iron with the oxyacetylene flame. For many years cast-iron cutting was considered almost impossible, but now with proper apparatus and technique the job can be done both successfully and economically.

Included is discussion of proper types of equipment, preheating conditions, cutting positions, need of adequate protective clothing, proper oxygen and acetylene pressures, etc.

Ask for Circular N-606, care of the above address.

L. W. DELHI JOINS HUNT, MIRK & CO.

L. W. Delhi, prominent member of the AMERICAN WELDING SOCIETY on the coast, has accepted membership in the firm of Hunt, Mirk and Co., 141 Second St., San Francisco, a pioneer Bay Area firm of engineers and contractors of more than 40 years' experience in their line. This announcement was made by Thomas J. Benny, senior member of the firm who has been active in the company since 1905.

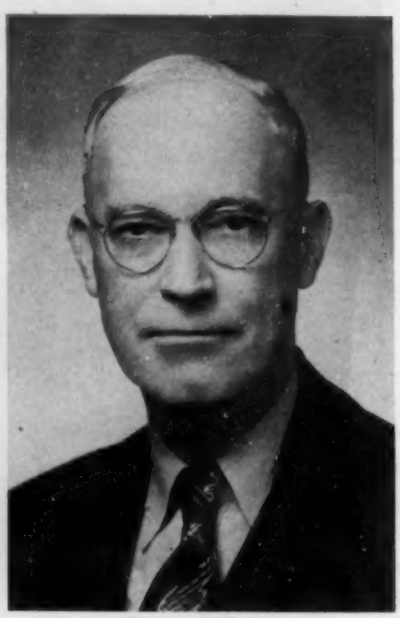
The Hunt, Mirk Co. was founded in 1903, and has been active continuously in the engineering and construction of steam power plants, marine engineering and all phases of steam distribution systems, electrical construction and some hydroelectric installations.

L. W. Delhi has concluded 22 years of service in the management of the Western Pipe and Steel Co. of California, which company was recently purchased by the Consolidated Steel Corp. of Los Angeles. Mr. Delhi was vice-president in charge of shipbuilding operations, which started at the beginning of the Maritime Commission program in 1939. The program consisted of the design and construction of more than 48 special all-welded C3-type vessels for the United States Maritime Commission, practically all of which were converted into specialized vessels for Army and Navy use.

The program also involved the fabrication of many thousands of tons of steel for other firms, as well as a comprehensive program of ship repair work for the Navy and War Shipping Administration.

Mr. Delhi has been one of the outstanding proponents of the use of automatic arc welding, not only in the construction of ships, but also in boiler drums, pen stocks, oil refinery equipment and other quality plate work, and has been particularly active in the development and use of the automatic electric arc weld. He has long been active in promoting the interests of the AMERICAN WELDING SOCIETY on the Pacific Coast, having served two years as Regional Vice-President, and is currently serving as National Director of the AMERICAN WELDING SOCIETY.

Mr. Delhi, having had much experience in the building and operation of a production organization with many and varied labor problems, was recently drafted to serve as president of the California Metal Trades Association. This organization represents more than 350 central California metal trades firms employing approximately 26,000 men. The collective strength of the California Metal Trades Association is at present occupied in an endeavor to affect and maintain a peaceful and mutually satisfactory settlement of the labor difficulties now facing manufacturers in the Bay Area.



Thomas J. Benny

L. W. Delhi

Mr. Benny further states that the firm will now have a stronger financial structure with the association of Mr. Delhi and additional personnel with the Hunt, Mirk Co. The firm will expand its prewar activities and in addition to the general business of power plant and boiler installations, they expect to work in conjunction with a general contractor and a specialized welding service in order to be in a position to offer a more complete and integrated engineering contract service than heretofore.

It is also expected that the firm will continue to expand the lines of auxiliary equipment in order to be of additional service to its many customers.

It is not expected at this time that any shop fabricating facilities will be acquired, as the firm will be better served by using the many varied local facilities now available.

ELLIS PROMOTED

Richard Ellis, district manager of The Austin Co., engineers and builders, in the Pacific Northwest, has been named vice-president of the company, according to an announcement made recently by George A.

NEW LOW TEMPERATURE ELECTRODES

EutecTrode 28

A Coated Electrode for the Metallic Arc Welding of Bronze, Brass, Copper

For reduced production costs—can be used with AC and DC — deposits sound welds with good corrosion resistance — a close color match to red bronzes and yellow brasses—tensile strength 45,000 psi.

Bronze Castings welded with EutecTrode 28. This is the first electrode developed that can successfully weld copper, brass and bronze with an AC-DC metallic arc. Completely machinable, perfect color match, high tensile strength.

Take advantage of these improved EutecTrodes:

24—for cast iron—no preheat—AC-DC
24B—for cast iron—AC-DC
30—for copper—AC-DC
2100—for aluminum alloys—DC

and these EuteChroms:

2—for hard overlays on worn parts — AC-DC
4—for work-hardening overlays—AC-DC
6—for overlays on tool steel—AC-DC
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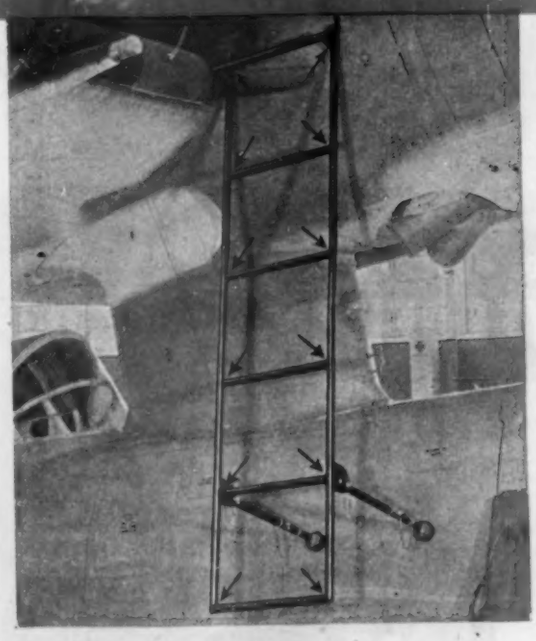
FREE Complete new booklet on fabricating with EUTECTIC Low Temperature Welding Rods.

Industry Endorses **EUTECTIC** *Low Temperature* **WELDING RODS*** **and FLUXES**

EUTECTIC *to the* RESCUE *at* *Curtiss-Wright*



THE SEAHAWK RESCUE LADDER

All parts (tubes and gussets) were set in a fixture and tack welded with EutecRod 16. The ladder was then taken out of the fixture and finished on the bench. This rod produces small fillets and prevents distortion.

*Trade Mark Reg. U. S. Pat. Off.

MANY American and British fliers downed at sea owe their lives to this famous Curtiss-Wright SC-1 Seahawk whose rugged rescue ladder was the helping hand that reached out to save them from certain death.

Extending from the fuselage to float the ladder folds into a compact unit. Although simple in design the fabrication was a headache to production engineers at Curtiss-Wright. Preliminary gas welding on the collapsible edges resulted in distortion and misalignment.

To lick this problem, EutecRod 16, which forms strong welds at 1300°-1600° F., was recommended. This low heat of application eliminated all danger of distortion and misalignment. The results obtained with this rod were so satisfactory that now it is also used in the production of control handles, brackets and parts of other planes manufactured by Curtiss-Wright including the latest model Helldiver.

WHAT IS EUTECTIC

EUTECTIC Low Temperature Welding Rods* are a new type of welding alloys, which—

1. Bond to base metals well below the base metal melting point. 2. Avoid the dangers of stress and distortion characteristic of fusion welding. 3. Form exceedingly strong bonds through surface alloying.

WHY NOT LET EUTECTIC LOW TEMPERATURE WELDING RODS SOLVE YOUR WELDING PROBLEMS. MAIL COUPON OR WRITE ON YOUR COMPANY LETTERHEAD FOR FULL INFORMATION.

EUTECTIC WELDING ALLOYS CORPORATION

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Please send me complete facts about EUTECTIC Low Temperature Welding Rods and Fluxes and information on how to purchase a selection of the 9 most important EutecRods for everyday use. Dept. JN1.

Name.....

Company.....

Address.....

Bryant, president, following the annual meeting of stockholders.

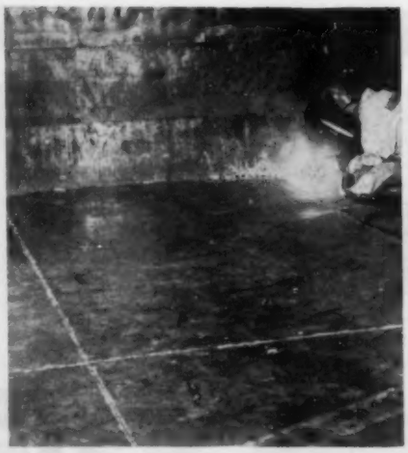
Mr. Ellis, joined the Austin organization at Seattle as structural engineer in 1924 and served as district engineer from 1931 to 1940, when he was named acting district manager. In this capacity, he was directly responsible for coordinating the design and construction activities of the Boeing Aircraft Co.'s Seattle and Renton plants and wind tunnel, as well as other extensive activities in the pulp and paper industry and other manufacturing fields and for the Army.

Mr. Ellis was graduated from the School of Architecture, Harvard University, and is a past-president of the Seattle Section of the American Society of Civil Engineers. He is also a member of the AMERICAN WELDING SOCIETY.

LEAD WELDING WITH THE CARBON ARC

In preparing a room at Hobart Trade School for installation of a 250,000-v. X-ray machine for testing of metals and welds, it was necessary that the floor and walls be lined with sheets of 1/8-in. lead to absorb the rays of the X-ray equipment and protect the area adjoining the testing room.

The walls were covered by lapping the lead sheets and nailing, but to lap the lead on the floor would result in bumps and eventual wearing and breaking of the lead. The floor is to be covered with asphalt tile blocks and a smooth even job of laying the lead sheets was necessary.



The edges were butted and joined by arc welding, using a carbon arc torch and strips cut from the lead sheets for filler rod. Welding current of 15 amp., 15 v. was used from a 300-amp. arc welding machine, but fitted with a Hobart Thinweld attachment connected to the welding circuit to reduce the amperage to the 15 amp. required to weld the lead. Joints were welded at the rate of 24 to 30 in. per minute by puddling the lead filler strips with a slight weaving motion. This work, of course, must be done in the down-hand position and well backed up with steel or copper. In this case the lead sheets were being laid on a steel floor which formed a perfect backing.

SCOTT JOINS ALLOY RODS CO.

P. D. Scott has joined Alloy Rods Co., as manager of the Tool Steel Division.

Mr. Scott was recently with the Welding Equipment and Supply Co. in Detroit and is quite well known for his past successful activity in the welded repair and fabrication of tools and dies.

Mr. Scott's coming with Alloy Rods Co. has inaugurated an intensive program to bring the tool steel welding possibilities to the attention of many companies and corporations not now enjoying the vast savings possible in this field.

COATED FIBERGLAS CLOTH OPENS NEW HORIZONS

Fiberglas Cloths, possessing a combination of characteristics and properties found in no other textile material, are giving new utility to coated fabrics for a virtually unlimited field of application.

These Fiberglas Cloths are woven from yarns of extremely fine, strong, flexible filaments of glass. . . inorganic, noncombustible, nonstretching and nonshrinking, resistant to oils, corrosive vapors and common acids. Furthermore, the tensile strength of Fiberglas Cloths is far greater than that of incombustible or natural-fibered fabrics of comparable thickness. They are being used for welding curtains. Owens-Corning Fiberglas Corp., Toledo, Ohio.

. . . is THIS your cleaning problem?

Obtaining The "No-Water Break Surface" On Aluminum

You can speed production, reduce rejects and more easily demonstrate the advantages of resistance welding if you clean and chemically deoxidize aluminum surfaces with specialized Oakite materials. Oakite aluminum cleaners thoroughly remove oils and greases acquired during earlier forming, fabrication or handling operations. After rinsing, the Oakite-degreased assembly shows that vital "no-water break surface"...ready for the recommended Oakite deoxidizing treatment. Write TODAY for complete details. Ask for the Oakite Surface Preparation Manual!

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AIR, FOOT or MOTOR Operated Press Type Welders of All Sizes.

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Transformers of all types.

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NEW Welding News is published bi-monthly for Production Minded Welding Men. It is distributed free of charge and contains interesting articles on the latest practices in the Resistance Welding field, and illustrates machines of unique design.

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Manufactured in CANADA by ENGLISH ELECTRIC COMPANY of Canada, Ltd., St. Catherines, Ontario
District Offices: Montreal, Toronto, Ottawa, Kirkland Lake, Vancover. Representation in Halifax, Winnepeg, and Edmonton.
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R. DAVID THOMAS, JR., ELECTED VICE-PRESIDENT OF ARCOS CORP.

R. David Thomas, Jr., director of research and engineering of Arcos Corp. since 1940, has been elected vice-president of the company, manufacturers of alloy electrodes.

The Arcos Research and Engineering Dept., which he will continue to head, has grown under his direction to be recognized generally as the outstanding authority on alloy weld metal in the country.

Mr. Thomas, who is a graduate of Cornell University and holder of a Master's Degree in Chemical Engineering from that institution, is a member of the AMERICAN WELDING SOCIETY, American Society for Testing Metals, American Society for Metals and Franklin Institute.

In addition to teaching courses in the metallurgy of welding at Drexel Institute and Temple University, Mr. Thomas has written numerous articles for the technical press, and has delivered a number of talks before the AMERICAN WELDING SOCIETY and other technical societies on subjects relating to the welding of stainless alloys.

R. David Thomas

During the war he participated actively on committees involved with the welding of armor, and is a member of the U. S. Army Subcommittee for welding of Armor, the Face-Hardened Armor Subgroup, the Electrode Subgroup and the Research Subgroup. He has been assigned the responsibility of preparing the report on the production of armor welding electrodes during the war for War Dept. archives.

He acts as adviser to the National Research Council, is a member of the Advisory Board of Engineers Digest, serves on the AMERICAN WELDING SOCIETY, American Society for Testing Materials Subcommittee on Copper Alloy Electrodes, and has done considerable work for the AMERICAN WELDING SOCIETY, American Society for Testing Metals Subcommittee on Stainless Electrodes in the formulation of specifications to be issued by that committee.

BRIEHL JOINS HARRIS CALORIFIC

The Harris Calorific Sales Co. of Chicago, Ill., has announced that Neil J. Briehl has joined the organization in the capacity of sales manager. Mr. Briehl brings to the Harris Calorific Sales Co. 20 years of experience in the welding field. He is well known and liked throughout the industry.

WELDING ACCESSORIES

The Hobart Brothers Co., Troy, Ohio, is announcing a complete new line of arc welding accessories for the welding trade. Everything for the welder is described and illustrated in a folder just released, DM-709. All and many difficult to find items are properly identified with catalog numbers for simplification in ordering. Copies of this folder will be sent free by the manufacturer. Request Folder DM-709.

BEHAVIOR OF FERRITIC STEELS AT LOW TEMPERATURES

This Report, issued in two parts, covers the extensive data resulting from experimental work carried out at the University of Kentucky as a War Metallurgy Committee project, but there is much data from other sources. Prepared by Dr. H. W. Gillett, Battelle Memorial Institute, and Francis T. McGuire, University of Kentucky, there is first an extensive discussion of the project, the materials included and the data resulting from the intensive experiments. Part II, the larger portion of the Report, gives the data developed with a large number of figures and charts.

The work was intended to secure a comprehensive set of experimental data on the low-temperature behavior of commercial, national emergency, S.A.E. and similar steels. It was felt some of the points would clarify the relation of composition, heat treatment, grain size, etc., to low-temperature behavior.

Part I has some 56 pages, with extensive tabular material and references, etc. Part II with some 250 diagrams, photomicrographs, etc., covers 156 pages. Page size is $8^1/_2 \times 11$ in., bound separately in heavy paper cover. Copies of the complete Report (two parts) can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa., at $4.00 per copy.

"HE NEVER FIRED A BLANK CARTRIDGE IN HIS LIFE"

Vice Admiral Howard L. Vickery received the James Turner Morehead Medal at a dinner in New York attended by most of the heads of the Maritime shipyards in the country. This medal was presented to Admiral Vickery former vice-chairman of the U. S. Maritime Commission, for his outstanding service in building America's bridge of welded ships. Vice Admiral Emory S. Land, his former chief, also paid tribute to Admiral Vickery for his leadership in adapting the use of welding and gas cutting processes to quantity production of America's wartime merchant fleet.

Left to Right Are Mr. Gibson, Admiral Vickery, G. L. Carter, I.A.A. president, and Admiral Land

Mr. Charles DeWolf Gibson, vice-president of the Air Reduction Co. and former president of the International Acetylene Association, presided, and in introducing Admiral Vickery said of him, "He never fired a blank cartridge in his life." Admiral Vickery is a member of the Welding Research Council and has presented several papers and reports before the AMERICAN WELDING SOCIETY.

LINCOLN ADDS TO FIELD STAFF

In line with its program for expanding the staff of field welding engineers to serve all users of welding, The Lincoln Electric Co., Cleveland, Ohio, announces the addition of the following district office representatives.

Omer W. Blodgett has been appointed welding engineer for the Grand Rapids, Mich., area. Blodgett is a graduate of the University of Minnesota where he received his B.M. degree in 1941, and has done considerable work in the field of machine and structural design. During the past four years he was welding superintendent for the Globe Shipbuilding Co., Superior, Wis., one of the three outstanding maritime yards in the United States from the standpoint of welding produc-

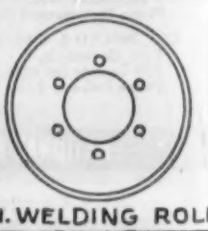
(Continued on page 266)

"ELECTROLOY" for RESISTANCE WELDING

Butt
Flash
Spot
Seam
Projection

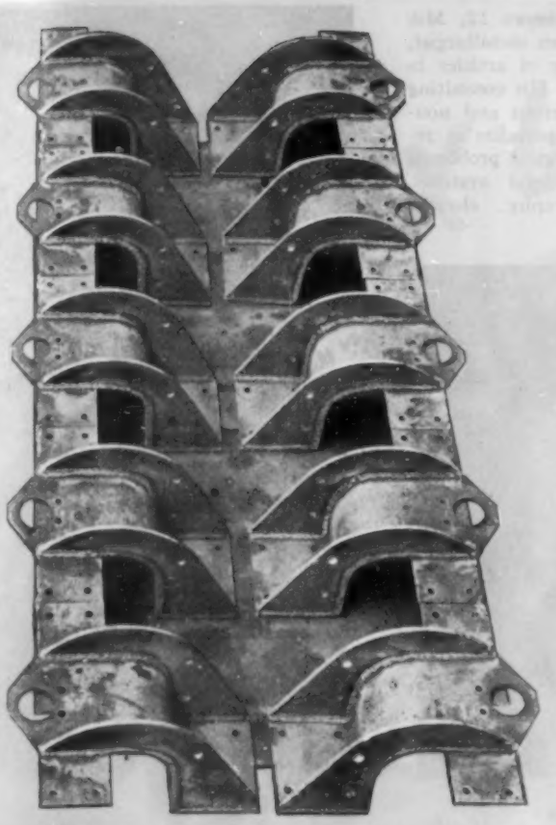
ELECTROLOY

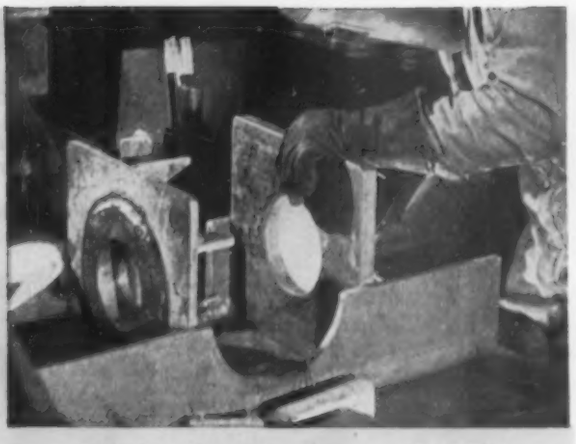
Catalog and prices on request



OFFSET HOLDER

THE ELECTROLOY CO. INC. 1600 SEAVIEW AVE. BRIDGEPORT, CONN. WELDING ROLL





FOR TACK WELDING — in any position — 3/16" AP gives perfect results; quick, deep penetration, eliminating humps.

FOR INDUSTRIAL FABRICATION — in volume production, 3/16" AP provides fast downhand deposition and enables the operator to switch to vertical and overhead work without stopping to change electrodes.

FOR PIPE WELDING — here again, 3/16" AP is a big money-saver for butt welding and joining all types of fittings with its smooth-flowing, deep penetrating arc.

CALL YOUR P&H REPRESENTATIVE

P&H makes a production-proved electrode for every welding requirement: for all mild, alloy and stainless steel applications, cast iron and for building up and hard surfacing.

ON CONSTRUCTION WORK— 3/16" AP ends the need for frequent time-wasting changes to smaller electrodes when working from downhand to out-of-position welds.

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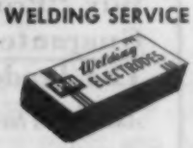
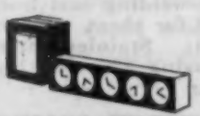


Welding Electrodes

Welding Positioners



Welding Production Control Systems

Electric Hoists

Captain L. J. Cogan

(*Continued from page 262*)

tion. In the above capacity, he supervised the operations of 400 welding operators. Blodgett is a member of Tau Beta Pi, honorary engineering fraternity, and the AMERICAN WELDING SOCIETY.

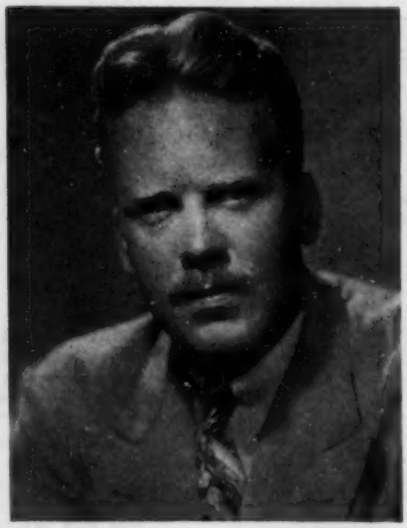
Captain L. J. Cogan, recently released from the United States Army, has returned to his duties as welding engineer in the Philadelphia area, with office at 3938 Market St., according to an announcement from the company's home office at Cleveland, Ohio.

During his Army service which began in 1943, Captain Cogan was assigned to research and development in the office of the Chief of Ordnance, as a welding engineer, and represented the department on a number of technical and advisory committees including the Ordnance Welding Committee and the A.W.S.-Army Ordnance Advisory Committee.

Prior to his war activities, Mr. Cogan had been associated with Lincoln in its Philadelphia office from 1935. The Philadelphia office was recently removed from N. Broad St. to the above new address.

ZAPFFE BECOMES CONSULTANT

Carl A. Zapffe, M.S., Sc.D., announced the opening on January 1st of a consulting office and research laboratory at 6410 Murray Hill Road, Baltimore 12, Md. Mr. Zapffe is a well-known metallurgist, having written a number of articles in THE WELDING JOURNAL. His consulting service will deal with ferrous and nonferrous metals and will specialize in research programs, metallurgical problems, defects in metals, gas-metal systems, stainless steels, fractography, electrochemistry and welding.



Carl A. Zapffe

Mr. Zapffe is a graduate of the University of Minnesota. He also holds a Bachelor's Degree in Metallurgy from the Michigan College of Mining and Technology, a Master's Degree in Metallurgical Engineer from Lehigh University, and a Sc.D. from Harvard University. He received the 1940 Proctor Memorial Award from the American Electroplaters Society.

He has published some 40 papers on gas-metal reactions, physical chemistry of steel making, welding, electroplating, vitreous enameling, crystallography, and a new technique of the author's invention called "Fractography."

VICTOR ELECTS TWO VICE-PRESIDENTS

The many friends of E. A. "Ernie" Daniels and E. O. "Ed" Williams will be glad to learn that their years of loyal and able service have been rewarded by their recent election to vice-presidents of Victor Equipment Co.

Ernie Daniels

Ed Williams

Ernie Daniels, formerly general sales manager, becomes vice-president, in charge of Sales, and Ed Williams, formerly district manager, with offices in Los Angeles, becomes vice-president and manager of the Southern California District.

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4 for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

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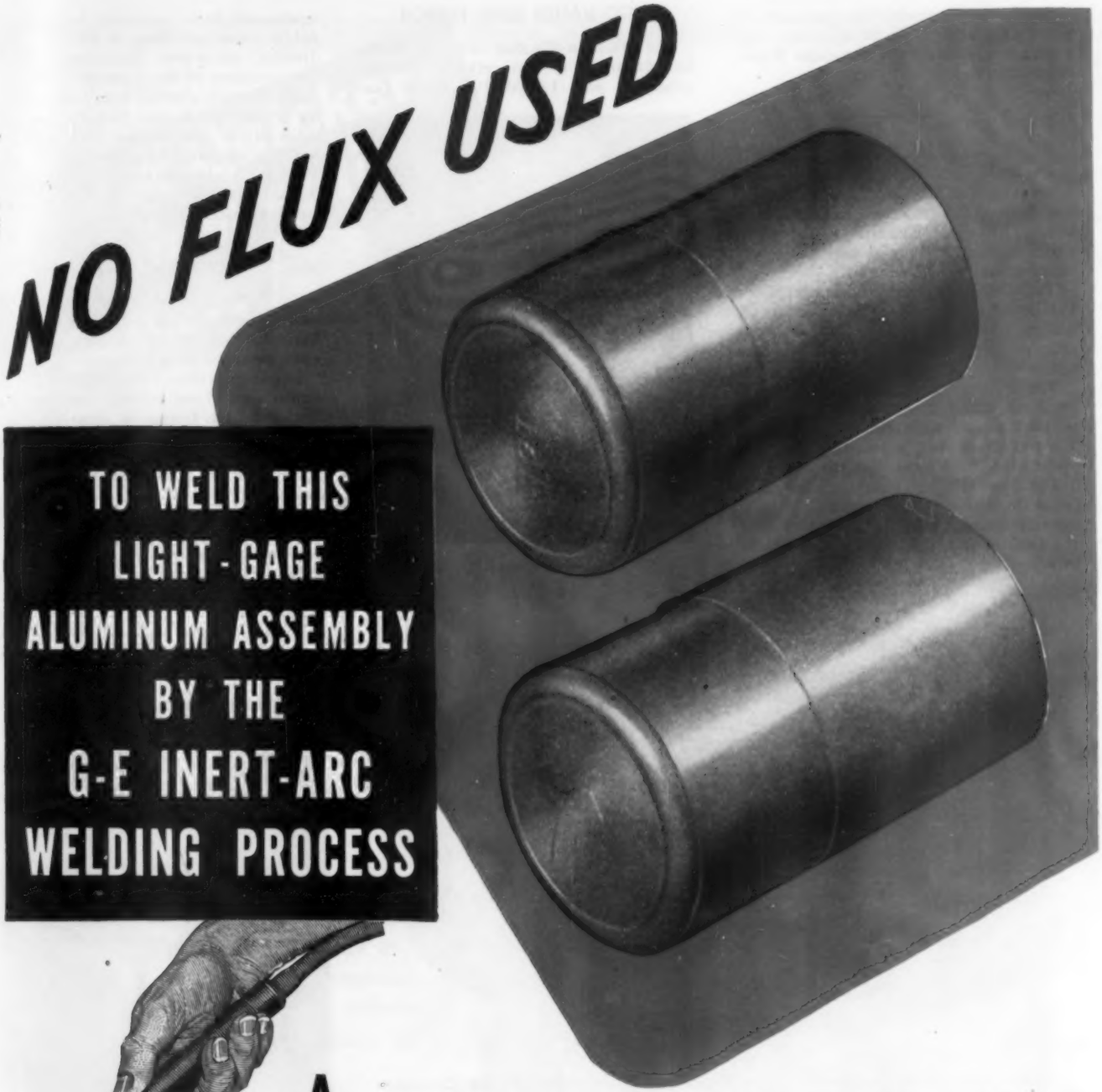
TO WELD THIS LIGHT-GAGE ALUMINUM ASSEMBLY BY THE G-E INERT-ARC WELDING PROCESS



NO. 1 in a series of case studies showing the potentialities of the G-E Inert-Arc welding process.

As a contribution to an important war job, G-E welding engineers were asked to develop a method of successfully welding a cap of 0.030- to 0.040-inch aluminum to a cylinder of the same material 0.060 to 0.080 inch in thickness.

Although several methods offered possibilities, tests proved that the new G-E Inert-Arc* welding process, using a-c power and using argon as the shielding medium, could not only meet the tough specifications but could also complete the required 4 inches of weld in as little time as *nine seconds*. As a result, this process was selected by the manufacturer, and today, eleven G-E Inert-Arc equipments are speeding the output of these high-priority assemblies.

If you are fabricating aluminum, magnesium alloys, stainless steels, or other hard-to-weld metals or alloys, investigate the new production possibilities of this process. For complete details or specific recommendations, get in touch with the G-E arc-welding distributor in your locality. Or, write *General Electric, Schenectady 5, N.Y.*

* Inert-gas shielded arc welding

GENERAL ELECTRIC

672-64-8748

Daniels started with the company 18 years ago, and Williams 16 years ago. Both are members of the AMERICAN WELDING SOCIETY.

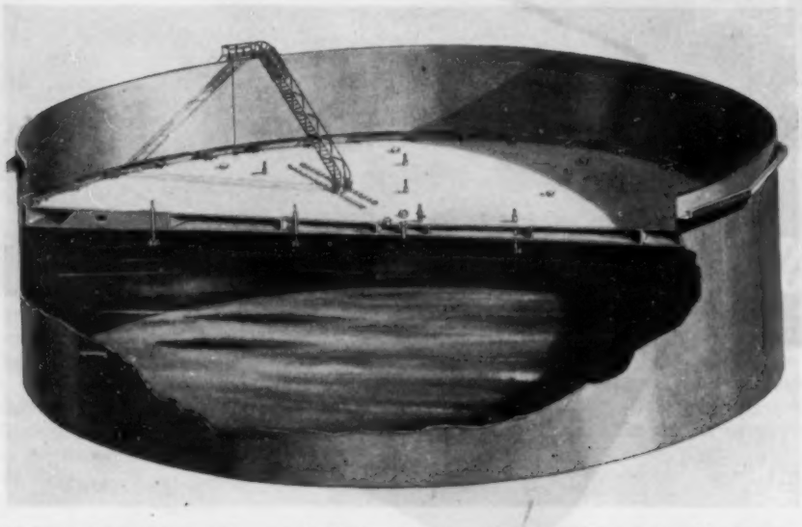
HORTON FLOATING ROOF

An improved Horton Floating Roof, of double-deck construction has been developed by the Chicago Bridge & Iron Co., Chicago, Ill. It is used on flat-bottom tanks storing volatile liquids.

The double-deck construction insulates the liquid and eliminates practically all boiling, thus extending the range of products previously stored in floating roof tanks.

The bottom of the deck is sloped up toward the center and the roof is designed to vent all air from beneath the deck. The top of the deck is smooth and slopes toward the drain located at the center.

The Horton seal closes the space between the tank shell and the deck. A sealing ring forms a long sliding contact with the tank shell and is joined to the deck by a continuous gas-tight curtain.



Cutaway View of the Improved Horton Floating Roof Developed by the Chicago Bridge & Iron Co., Chicago. This Type of Roof Is Being Used to Reduce Evaporation Loss from Volatile Liquids and Chemicals Stored in Flat-Bottom Tanks

REGO NAMES JERRY FRENCH

The Bastian-Blessing Co., Chicago, manufacturers of oxyacetylene welding apparatus and Liquid Petroleum Gas equipment, have appointed Jerry French public relations director for the Rego division, announced Ellsworth L. Mills, vice-president of the company.

Jerry French

Mr. French, who has been with the firm for several years, was formerly the publisher of the *Merchandise Mart Review*, a business magazine sponsored by Marshall Field & Co. He will head up a greatly expanded advertising and publicity program for The Bastian-Blessing Co.

AIRCO TECHNICAL SALES DIVISION

C. D'W. Gibson, vice-president in charge of sales for Air Reduction Co., New York, has announced the organization of a new technical sales division of the firm.

The new division, which replaces Airco's former applied engineering department, is headed by Dr. George V. Slottman, with the company 10 years. He holds degrees from Massachusetts Institute of Technology and the University of Berlin, is a former professor of chemical engineering at M.I.T., and has done a great deal of work in the theory and application of gaseous combustion in steel mill operations in the United States and abroad. He is a Past-Chairman of the New York Section, A.W.S.

Mr. Gibson also announced that S. D. Baumer and E. V. David, who have been assistant managers of the applied engineer-

Dr. George V. Slottman

TIP CLEANING **DRILLS**

Mounted in Knurled

BRASS *Handled*

LARGE STOCK
PROMPT DELIVERY
NO RATING REQUIRED

DISTRIBUTORS WANTED

NEW MEXICO STEEL CO.
Box 691, Albuquerque, N. M.

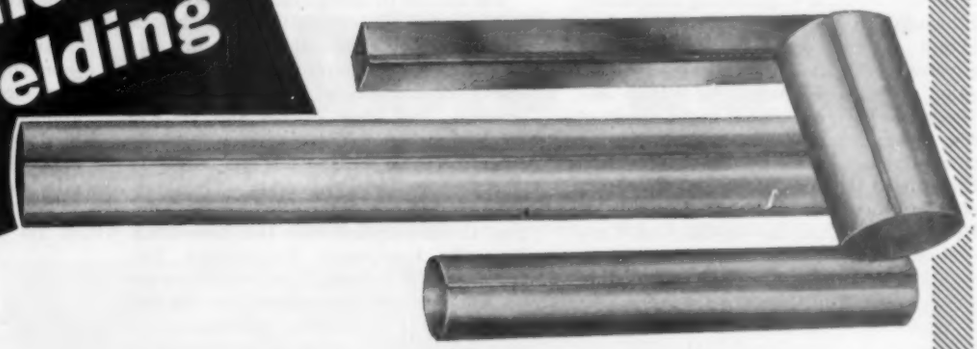
NET MONTHLY ADVERTISING RATES

Black and White *Effective Jan. 1, 1946*

Space	One Insertion	Three Insertions	Six Insertions	Twelve Insertions
*Full Page	$150	$135	$125	$115
Half Page	85	75	70	65
Quarter Page	50	48	45	40
Eighth Page	33	30	25	22
*Inside Preferred	170	155	145	135

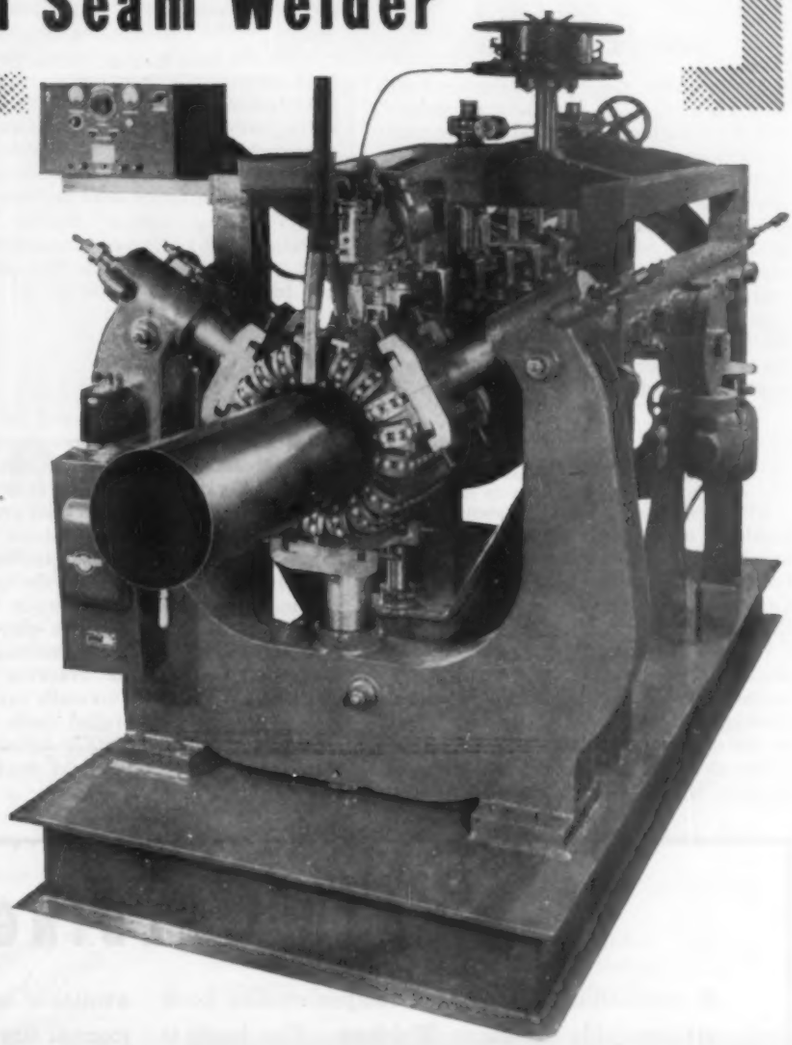
*10% Extra for bleed full pages. Color $50 extra per color added

for a Quicker Better Welding Job . . .



Berkeley Continuous

Longitudinal Seam Welder



Only with the "Berkeley" can you get welding speeds up to 250 in. per minute . . . not just for one welding job, but all day long.

Preformed tubes, 4" to 36" in diameter, are fed into the back of the fixture and emerge at the opposite end a completed product . . . with continuous, uniform welds, of X-ray quality that require no finishing.

For rounds, squares and a variety of shapes, there's no substitute for the "Berkeley" used in combination with the automatic submerged electric arc.

Model illustrated is Type 2C. Will handle preformed tubes 10" to 20" in diameter.

Write us today for details regarding the best type for your purpose.

PENN TOOL & MACHINE CO.
DANVILLE, ILLINOIS

ing department, are assistant managers to Dr. Slottman in the new sales division.

Mr. David was graduated from the Winterthur (Switzerland) Institute of Technology, and served with the Newport News and Federal shipbuilding companies, International General Electric, Hartford Steam Boiler, New York Steam, and government inspection services before going with Air Reduction in 1929. Mr. David has been prominent in the affairs of the AMERICAN WELDING SOCIETY and is currently Chairman of the Convention Committee of the SOCIETY and a member of the National Program Committee. He is a Past-Chairman of the New York Section, A.W.S., and has served for a number of years on the Board of Directors and Finance Committee.

After schooling at Princeton and the University of Pittsburgh, Mr. Baumer spent several years in gray iron and steel foundry production. Then he went with Bethlehem Steel for 14 years, in both production and maintenance. He joined Air Reduction in 1941. He is a member of the AMERICAN WELDING SOCIETY.

SUSTAINING MEMBER

The Lummus Co., 420 Lexington Ave., New York 17, N. Y., engineers, constructs and places in initial operation chemical and petroleum refining plants. They have built thermal and catalytic cracking plants, solvent lube oil plants, atmospheric and vacuum distillation units, 100 octane aviation gasoline plants, butadiene, styrene, ethylene, alcohol and many other petroleum and chemical refining plants. Lummus has an enviable performance record in the design and construction of these plants for quick delivery and rapid meeting of performance requirements.

POSTWAR PASSENGER CAR

The first postwar-built passenger car, heralding a new era in luxurious comfort in railroad travel, was delivered in Detroit today by the builders, Pullman-Standard Car Manufacturing Co., to the New York Central System.

On each of the end bulkheads are framed reproductions in color of paintings by famous artists. An electrically operated drinking water cooler is at the men's end of the car.

The gleaming new car, 85 ft. long over couplers, is built of high-tensile, low-alloy steel, of welded construction, with stainless-steel exterior sheathing. The wide sections above and below the windows are fluted but the curved roof is of flat stainless-steel sheathing.

The utmost in riding comfort is provided by the use of rubber draft gears, tightlock couplers which eliminate shocks and jars in starting or stopping and four-wheel trucks of coil-spring design with roller bearings, unit clasp brakes and vertical shock absorbers. The car has a vestibule and retractable steps at one end only. It seats 64.

The interior was styled by Henry Dreyfuss, in conjunction with the New York Central's Equipment Engineering Department. It is designed to provide every possible comfort and convenience for the passenger. The rotating, reclining seats, with adjustable foot rests, harmonize in color with the shade used on the walls and ceiling of the section in which they are placed.

In each car of this series two basic colors are used, the center section varying in tone from the end sections. Blues, rusts and coca-brown are the three basic colors used in the 153 coaches, of which this is the first.

With the wide luggage racks, which extend continuously from end to end of the passenger compartment, are incorporated individually controlled fluorescent lights over each of the seats. The center light fixtures, mounted on longitudinal air-conditioning diffusers, may be dimmed for night lighting, during sleeping hours. Lavatory and toilet accommodations for men are at the vestibule end and for women at the opposite end.

ELECTRODE

A new all-position mild steel electrode, called Airco No. 312, has been announced by Air Reduction Sales Co., 60 East 42nd St., New York 17, N. Y. It was designed primarily to prevent underbead cracking in the welding of hardenable steels.

Laboratory tests and field applications indicate this electrode is satisfactory for welding: Low-alloy, high-tensile steels, particularly in heavy sections where preheat must be used with conventional type electrodes to minimize cracking; free machining steels which normally run quite high in sulphur; cold-rolled steels where excessive porosity is normally encountered with conventional type mild steel electrodes.

For material to be vitreous-enameled after welding, this electrode makes possible production of highly satisfactory enameled surfaces without any preheat treatment prior to the enameling operation, something that is impossible with conventional mild type steel electrodes.

Airco No. 312 should also prove much more suitable than conventional mild type steel electrodes on low-alloy or mild steel applications where stress relieving would be desirable but cannot be accomplished, either due to lack of facilities or the magnitude of the application.

ANNUAL MEETING

In conjunction with the Metal Congress and Exposition, the American Welding Society will hold its Annual Meeting in Atlantic City during the week of November 17th. Headquarters for the Society will be at The Ambassador.

The National Program Committee is making every effort to make the first Postwar meeting of the Society an outstanding success. Plans are being developed to include a five-day technical session program, starting with the customary President's Reception on Sunday, November 17th. Plans are being considered for holding an Annual Dinner on Thursday Evening as in previous years. Preliminary indications are that there will be several sessions dealing with Research, and also sessions on shipbuilding, structural work, pressure vessels, railroads, gas cutting, maintenance and repair, aircraft welding, resistance welding, hard facing, production and several others.

The Exposition promises to be one of the largest ever held by societies interested in metals and their uses.

The hotel situation has been materially improved over the war years and members can be assured of hotel accommodations, providing they make their reservations early. Nearly all of the rooms at The Ambassador have twin beds and bath. Prices are somewhat higher than in prewar years, but very much in line with resort hotels.

Consideration is also being given to ladies entertainment, although no details can be announced as yet.

The Welding Research Council will hold its usual Conference of University Research Professors. There will be a Section Officers Conference and the usual committee meetings.

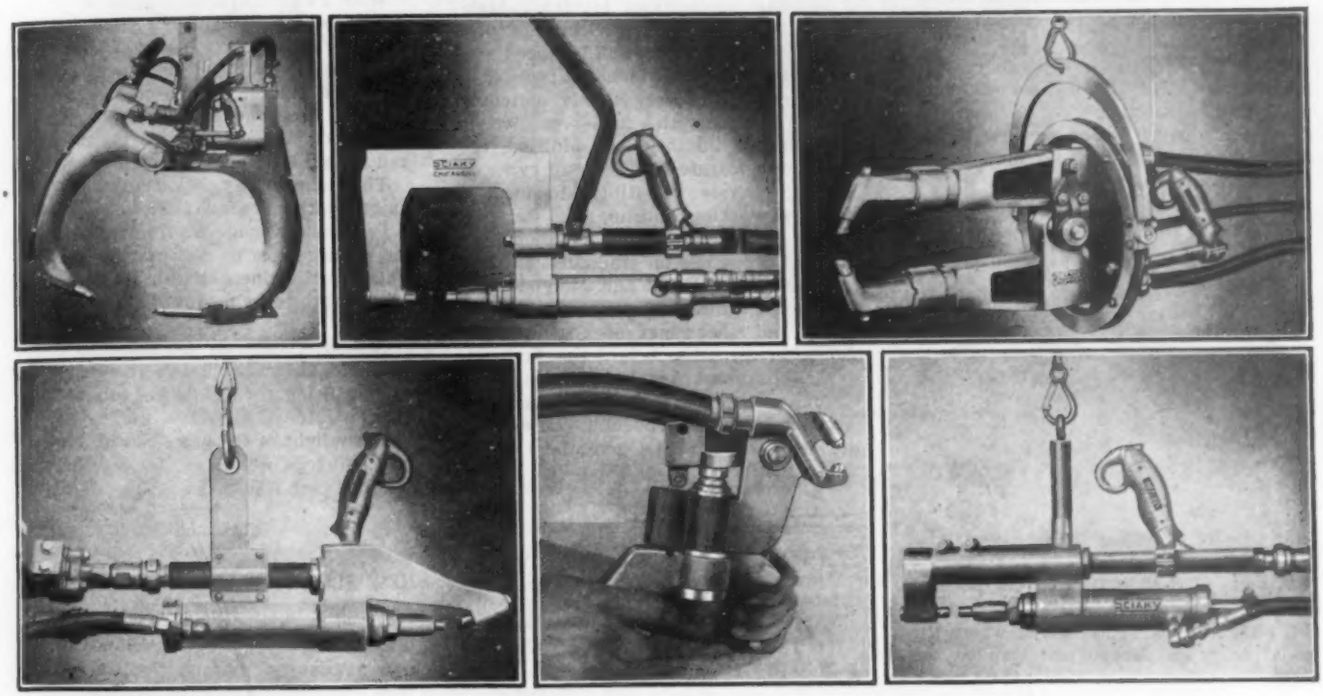
—FLASH WELDING BOOK—

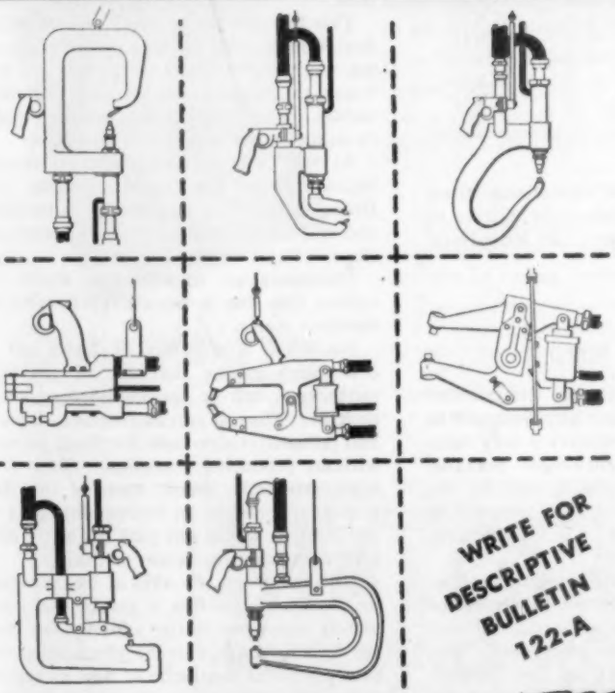
A translation of the most comprehensive book yet available on Flash Welding. The book is available as a separate pamphlet of 55 pages, journal size, copiously illustrated. Price $1.00.

AMERICAN WELDING SOCIETY
33 West 39th St., New York 18, N. Y.

NOW IT'S SPOT WELDING GUNS

Sciaky builds 'em LIGHT - FAST - ADAPTABLE - STURDY in both pneumatic and hydraulic types - to handle every job





THE SPOT WELDING Gun is now the weapon to "mow down" your old enemies—high operating costs and slow production.

Sciaky guns are designed with a simplicity which *cuts weight* without sacrificing strength or performance. Further advantages are!

- ★Basic gun types are adaptable by changing yoke, suspension or handle position.
- ★Ample provision for cooling electrodes, yokes and jaws.
- ★Removable tips . . . easy replacement or mounting of different types.
- ★Cylinders on both "alligator" and "C" type guns can be made for different strokes.
- ★Special construction positions moving electrode very close to border of gun.
- ★All moving parts are protected by properly located felt seals.
- ★Hydraulic guns use water system with special booster—system is automatically refilled in case of leakage. All parts contacting water are made of rustless materials.

WRITE FOR DESCRIPTIVE BULLETIN 122-A

SCIAKY BROS.

Makers of Quality Resistance Welding Equipment.
Offices in New York, Washington, Detroit and Los Angeles. Representatives in principal cities. Plants in London and Paris.

ARMY (E) NAVY

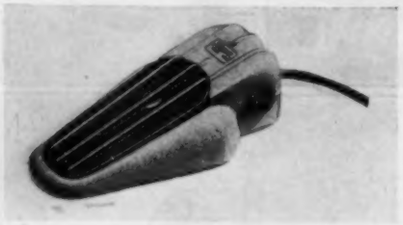
NEW PRODUCTS

The Society assumes no responsibility
for the validity of claims in this Section

THE NEW TIME-O-LITE FOOT SWITCH

A new foot switch with many and varied uses has just been announced by the Industrial Timer Corp., 117 Edison Place, Newark 5, N. J.

Industrially, the uses of the foot switch are almost unlimited; drill presses, sanders, lathes, spot welders, jig saws, circular saws and dental lathes or any motor-driven equipment up to 1 hp. may be controlled with this new foot switch. Hands are left free for other operations, which is a



safety factor as well as a time saver and a convenience.

A neon pilot light on the foot pedal—inside the switch—not strong enough to fog photographic paper, shows where the pedal is in the dark—"just step on the light."

It operates on any a.-c. circuit. This switch incorporates a heavy-duty snap-action, single-pole, double-throw switch. Silver contacts are used throughout. Two black outlets, each with 1500 w. capacity (total 3000 w.), operate electrical equipment when pedal is depressed. One red outlet (1500 w. capacity) turns electric equipment off when pedal is depressed. The switch operates with a minimum of noise.

HIGH-TENSILE ELECTRODE

Metal & Thermit Corp. announces the addition of two entirely new groups of high-tensile arc-welding electrodes to the Murex line.

These new electrodes, it is claimed, are the first to provide two complete series of all-position high-tensile electrodes; one having an A.W.S.-A.S.T.M. XX10 type of coating and the other a coating of the A.W.S.-A.S.T.M. XX13 variety. Individually, there are eight electrodes in all, one classified as A.W.S. Grade E-7010, one E-8010, one E-9010 and one E-10010, all for use on direct current with reverse polarity, and a companion electrode to each having an XX13 coating for use on alternating current or on direct current with straight polarity.

Developed to meet the requirements of fabricators of power plant piping and equipment, but applicable to a variety of welding applications involving high-tensile steels, these new electrodes provide a wide range of well-balanced mechanical properties and make it possible to select weld metal very closely matching many high-strength steels in tensile strength and ductility. In addition, the all-position feature and the two types of coating provide versatility to meet a variety of working conditions.

The electrodes depend for their mechanical properties on graduated alloying contents of chromium and molybdenum. The names indicate both the deposit analyses and the types of coatings. As shown in the table below, the first numeral in the name of each electrode is twice its chromium content; the second numeral, twice the molybdenum content and the last two numerals give the type of coating.

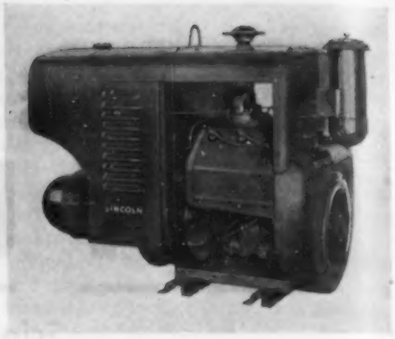
New Murex Electrode Type	Chromium Content, %	Molybdenum Content, %	A.W.S.-A.S.T.M. Type of Coating
1110	0.5	0.5	XX10
2110	1.0	0.5	XX10
4110	2.0	0.5	XX10
4210	2.0	1.0	XX10
1113	0.5	0.5	XX13
2113	1.0	0.5	XX13
4113	2.0	0.5	XX13
4213	2.0	1.0	XX13

Further information concerning these electrodes may be obtained by writing to Metal & Thermit Corp., 120 Broadway, New York 5, N. Y.

PORTABLE WELDER

A new portable welder of the gasoline engine-driven type, especially designed to bring to the welding industry a very inexpensive, complete, lightweight portable welder for the price normally paid for the welding generator alone, is announced by The Lincoln Electric Co., Cleveland, Ohio.

Of particular value for welding applications in areas where electric power is not readily available such as farms, oil and gas fields, construction work, etc., this 200-amp. welder known as the "Shield-Arc Jr.," is of exceptionally compact design measuring 24 x 48 x 30 in. and weighing much less than the usual equipment of this type and size.



With a current range of from 40 to 250 amp., the machine can be used for the welding of light or heavy gage metal, for the repair of cast-iron structures such as engine blocks, for the construction of various contrivances or the repair or fabrication of tools and machinery parts, and for hard facing of worn parts.

This new welder has many new and unique features such as the following:

Provision is made on the output panel for three ranges of output current, continuous adjustment within these ranges being obtained by means of a simple speed control.

Generator controls are mounted inside an enclosed cabinet above the generator, cooling being through a fan mounted on the generator shaft.

Net weight of the new "Shield Arc Jr." engine-driven welder is 660 lb., shipping weight being 705 lb.

NEW FLUX IS WATER-THIN AT 800° F

Something quite revolutionary in silver-brazing fluxes has been developed and is now available for use in civilian production.

This flux known as Nu-Braze Wonderflux #4 melts and forms a protective coating over the metal surfaces at 480° F., well below the oxidation temperature of most metals. Thus, this flux *eliminates oxides by actually preventing their formation.*

At 800° F., the point where ordinary brazing fluxes first begin to melt, Nu-Braze Wonderflux is actually water-thin, and will readily flow through clearances as close as 0.001 in.

Possessing an unbelievable thirst for oxides, this flux is especially effective on stainless steels.

Nu-Braze Wonderflux #4 has a pH of 5-6 which means that for all practical purposes it can be considered completely neutral. Thus, it can be painted on parts and allowed to remain for long periods without producing corrosion. Since it is nonhygroscopic, should some of this flux remain trapped in an inaccessible part of the joint, it would not pick up water at a later date and thus cause corrosion.

Because it is water-thin at its operating temperature, this flux is gently and completely eased out of the joint by the molten brazing alloy, thereby eliminating the ever-prevalent headache of flux inclusions in brazed joints.

After it is melted, Nu-Braze Wonderflux #4 hardens to an extremely brittle glass which can usually be jarred from the

Poor Timing Always Means Trouble

(a moral that applies to resistance welding)

LIKE the unhappy wife in this domestic scene, many a product has been "burned up" because of bad timing. Good timing of the duration of the welding current, however, involves many factors—and not all of them can be accurately determined without the advice of an expert.

If you use magnetic contactors, for instance, should they be manually, mechanically or electrically timed? Should continuous current be applied to your material, or would it be better to use interrupted current? Questions like these are often asked of Mallory—and our engineers are glad to furnish answers. Get acquainted with us by asking for a free copy of the Mallory Resistance Welding Data Book. Meanwhile, observe these do's and don'ts:

The most comprehensive manual ever published on resistance welding methods, machines and materials! Free to those using resistance welding, when requested on company letterhead.

DO'S

1. Use magnetic welding contactors developed specifically for welding applications.
2. Have all timing devices suitably calibrated.
3. Use synchronous electronic timing controls for short timing periods or in welding materials having critical weldability.
4. When in doubt, check the Mallory Resistance Welding Data Book.

DON'TS

1. Never use non-synchronous timing devices for short timing (less than 4 or 5 cycles).
2. Do not employ non-synchronous timing devices for welding materials with critical welding characteristics such as aluminum, magnesium and brass.
3. Avoid expensive synchronous timing devices for long timing, non-critical applications.

In the United Kingdom, made and sold by MALLORY METALLURGICAL PRODUCTS LTD. (An Associate Company of Johnson, Matthey & Co. Limited) Hatton Garden, London, E. C. 1

P. R. MALLORY & CO. Inc.

MALLORY STANDARD RESISTANCE WELDING ELECTRODES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

brazed part. It is easily removed by either hot or cold water.

Nu-Braze Wonderflux #4 is manufactured by Sherman & Co., 197 Canal St., New York 13, N. Y.

TWEEZER SPOT WELDING MACHINE

The New BESCO Tweezer Spot Welding Machine is a portable unit weighing approximately 25 lb. To the cabinet—the size of a small radio—is connected a pair of insulated, forged copper tweezers and a foot switch. It plugs into 115 v., 60 cycle power supply and may be easily adapted to 220 v.

Its use is amazingly simple; its applications are unlimited for industries fabricating metal parts measuring 0.0005 to 1/8 in. round or thick.

To weld parts from 0.015 in. through 1/8 in. round, the machine is used with an auxiliary booster unit which increases the capacity of the equipment by 300%.

Heretofore the welding of tiny parts has been almost impossible because of the inherent difficulty in holding them in order to effect the weld. With the use of the tweezers, the electrodes may now be applied directly to the elements to be joined. The tweezers probe for the parts, hold and bend them, and weld.

Because the voltage used is low, and the current flows through the welding tweezers at about 1/1000 sec., the tweezers may be held in the hands with absolute safety. They will not heat up even after continuous usage.

The tweezer leads are flexible, plastic covered—are 18 in. long. With the use of the tweezers, oxidation is eliminated. The points require touching up only once a day.

To weld: set the voltmeter, hold the two pieces of metal to be joined with the tweezer tips, apply pressure, step on the foot switch and the weld is effected.

Complete catalog information is available from the manufacturer, Tweezer-Weld Corp., 280 Plane St., Newark 2, N. J. Patents are pending.

IMPROVED ELECTRODES FOR HARD FACING

One new and one improved shielded-arc electrodes, each of the type designed for specific hard-facing applications, have been announced by The Lincoln Electric Co., Cleveland, Ohio.

"Abrasoweld AC," designated as a hard-facing shielded-arc electrode, is designed for building up straight carbon steel, low-alloy steel or high-manganese steel with a self-hardening deposit to resist severe abrasion, battering and impact. Although specially designed for operation on alternating current, it may be used for both the industrial type and small, mass-market type welding machines and direct current.

Properties of weld metal of this new electrode are of the self-hardening type alloy which is semiaustenitic and abrasion resisting, and hardens very rapidly under conditions of impact and abrasion. Moderate peening will increase hardness as deposited from 20–40 Rockwell C to over 50 Rockwell C. The weld metal maintains its toughness and develops its maximum hardness only at the surface where it is cold worked. Thus at all times beneath the surface remains a cushion of softer metal which eliminates checking and flaking so common with abrasion-resisting metal produced by ordinary electrodes. The deposit is more resistant to corrosion than high manganese steel.

This new "Abrasoweld AC" electrode is available in 1/8-, 5/32- and 3/16-in. sizes and is furnished in 14-in. lengths.

"Manganweld A," suspended for the duration, has been improved and is now manufactured specially for reclaiming worn austenitic manganese steel parts containing 11 to 14% manganese. It is particularly well suited for use with d.-c. machines, and may be used with both the industrial type alternating current, and small, mass market type welding machine.

Generally recommended for flat work only, "Manganweld A" electrode produces a flat bead and melts uniformly with minimum spatter. The weld deposit is air toughening, remaining in austenitic state and retaining carbides in solution even during air cooling. The deposited metal has a resistance to abrasion and impact that is equal to heat-treated cast manganese steel. Weld metal, as deposited, has a hardness 5 to 10 Rockwell C and cold worked, a hardness of 45 to 50 Rockwell C.

"Manganweld A" is recommended for all resurfacing and building-up applications of high manganese steel and is sometimes applied only as top beads where an abrasion-resisting surface is required.

This improved electrode is furnished in 5/32-, 3/16- and 1/4-in. sizes and 14-in. lengths.

WELDED METAL-CUTTING SHEARS

The Heavy Machinery Division of The Cleveland Crane & Engr. Co., Wickliffe, Ohio, are introducing a line of power-driven metal-cutting shears that are new and radically different from all other shears now on the market. To be known as Cleveland Steelweld Shears, the new

machines employ a revolutionary pivoted-blade principle which makes possible several outstanding advantages and overcomes certain handicaps of present-day guillotine type shears.

There are no slides or guides to wear out of true and cause inaccuracies. The upper blade operates on two heavy pivot pins secured to the end housing and travels in a circular path.

A most valuable feature is the ease with which the knife clearance may be varied to suit the thickness of plate being cut. Turning a hand crank, conveniently located on the right end housing, changes the gap between the knives. A large dial indicator indicates the clearance in thousandths of an inch, and also shows the plate thickness that may be cut for any knife setting.

Steelweld Shears may be readily arranged for squaring, slitting or set at any intermediate position for notching, and firmly locked. This feature is included on all machines with standard 24-in. deep throats, but is not furnished on the smallest size, where the throat depth is 18 in.

Both frame and blade are of all-welded steel, one-piece construction. Because the knife adjustment is made by movement of the upper blade, there is no need of moving the bed as is customary with most shears. Consequently, the beds on Steelweld Shears are welded integral with the frames. Likewise, the large crown is welded to both end housings. This method of welding all parts of the assembly into a single integral unit provide maximum strength with minimum deflection, and assures permanent accuracy.

Steelweld Shears have been developed in various sizes for cutting plate of all thicknesses from 12 gage to 1 1/4 in. and for lengths from 6 to 16 ft. Speeds range from 60 strokes per minute on the smaller shears to 25 strokes per minute on the largest size.

BRONZE ELECTRODES

The Metal and Thermit Corp., New York, N. Y., announces a new Murex line of heavy-coated aluminum bronze and phosphor bronze electrodes. The new Murex electrodes make available a wide range of bronze alloy deposits varying in chemical analyses and in mechanical properties from high-tensile strength and ductility with comparatively low hardness, to medium strength with zero ductility and relatively high hardness. The deposits have good wearing and bearing characteristics and excellent corrosion resistance.

TO CROSS THE LAND . . . TO PIERCE THE SKY

1928 "Bell-hole" welding of pipe lines, where downhand position welds were not feasible, led to development by A. O. Smith in 1928 of the all-position electrode . . . a great stride forward in the art of welding.

1946 Everywhere vertical and overhead welding is necessary today—in erecting skyscrapers, fabricating bridges, building subways and ships—the SMITHway all-position electrode makes welding the builder's most modern production tool.

MILLIONS of SMITHway Certified Welding Electrodes are used by builders and manufacturers everywhere. More than 320,000 have been used daily in A. O. Smith plants alone . . . in the fabrication of steel products that range from the smallest and simplest to the largest and most complex.

For the proof of SMITHway Electrodes is in actual production—day-to-day plant and field operations, backed by the A. O. Smith program of welding research that never ends.

Write for the SMITHway Welding Catalog for detailed specifications of SMITHway Certified Electrodes and their application to specific welding jobs.

Mild Steel . . . High Tensile . . . Stainless Steel
WELDING ELECTRODES
made by welders . . . for welders

SMITHway A. C. WELDERS

Reduce Spatter . . . Eliminate Arc Blow. The expanded line of SMITHway A. C. Welders now includes six models—150-, 200-, 250-ampere capacity; and for heavy duty, 300-, 400-, and 500-ampere capacity. Write for prices and specifications.

SMITHway Certified WELDING ELECTRODES

A. O. SMITH Corporation

NEW YORK 17 • PITTSBURGH 19 • CHICAGO 4 • TULSA 3
HOUSTON 2 • DALLAS 1 • LOS ANGELES 14 • SEATTLE 1
INTERNATIONAL DIVISION: MILWAUKEE 1 • *In Canada:* JOHN INGLIS CO., LIMITED

The new types of electrodes including their uses are described by the company as follows.

Aluminum Bronze

Type AB 12, average Brinell hardness of deposit, 120: This is a general-purpose electrode providing a high-strength, corrosion-resistant deposit with exceptional "hot ductility" or elongation at red heat. It is well suited to the arc welding of manganese bronze castings and brass sheets as well as to "arc brazing" of dissimilar metals such as steel to cast iron, cast iron to bronze or copper and steel, and iron, bronze or brass to nickel alloys. Welds are free from shrinkage cracks and heavy sections may be welded without preheating.

Type AB 16, hardness of deposit, 160, combines high ductility and tensile strength with outstanding bearing qualities. This type is recommended for repair or fabrication overlays on bearing surfaces subject to shock or impact. Machinability is comparable to that of other nonferrous alloys.

Type AB 20, average hardness of deposit, 200, is designed to provide a deposit having the highest possible hardness and tensile strength without sacrificing ductility. It is recommended for repair, maintenance or fabrication overlays on machine parts subject to unusually severe service, such as building up worn heavy duty gears and repairing broken teeth. The deposit is also highly acid resistant and the electrode is widely used in building equipment for use in corrosive services.

Type AB 25, average hardness of deposit, 250, is intended for overlay applications requiring high hardness to withstand extreme wear and heavy pressures. It is used, for example, in building up bushings, bearings and slides operating against hardened steel which must stand up against heavy pressures and extreme wear. Frequently, worn cams can be built up with Type AB 25 without dismantling the machine.

Type AB 30, hardness of deposit, 300: This electrode provides an extremely hard deposit with exceptionally good bearing qualities. It is employed for overlaying dies for forming and drawing operations on carbon and stainless steels where freedom from scratching and galling of work is required. The deposit is hard enough to eliminate objectionable draw lines when used on die surfaces where the metal slides.

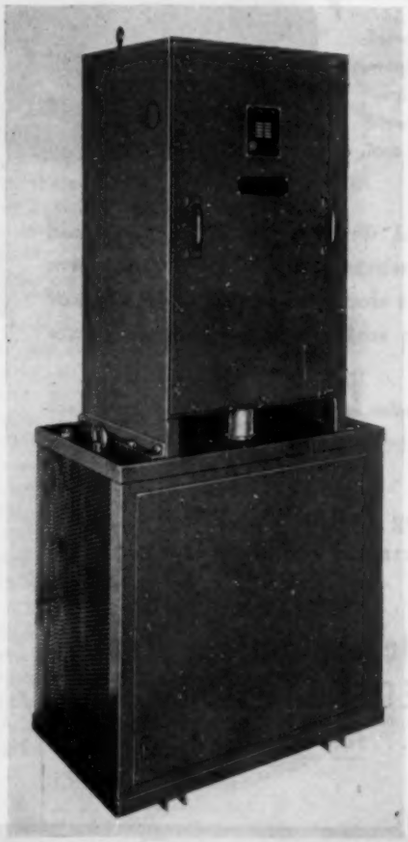
Phosphor Bronze

Type PB 57, hardness of deposit, 71: This is a phosphor bronze electrode which produces sound, homogeneous welds with tensile strengths of 30,000 psi. or more, depending on the base metal being welded. Welds in 8% tin phosphor bronze plate, fully annealed bend 180° in face and root bend tests without fracture. As an overlay, the deposit shows an average Brinell hardness of 57.

The electrode is recommended for high-speed, high-quality welding of bronzes, brasses, copper steel and both cast and malleable iron. It may be used in all positions—flat, vertical and overhead—for building up surfaces as well as for joining sections of these materials. It is widely used in such work as building up bearing surfaces, bronze casting repairs, cast-iron repairs, motor and ring maintenance, and repairs to piston rods, pump parts, locomotive guides and copper rivet heater blocks, in addition to welding of brass to steel, bronze to cast iron, copper to steel, galvanized iron and manganese steel.

POWER FACTOR REGULATOR

The Haug System Power Factor Regulator is announced by the Modern Control Equipment Co., 176 W. Adams St., Chicago. Connected to the lines of commercial power users, the makers state that it will raise the power factor by taking the magnetizing current off the line with a negligible cost in operation. . .that, by increasing the power factor, it will greatly reduce the monthly power bill . . . will increase low voltage to desired value where voltage was previously low due to poor power factor. Connected apparatus will function smoothly, resulting in more uniform and efficient operation of all motors and machines—particularly welding machines; and a substantial saving in man-hours, due to greater line stability and



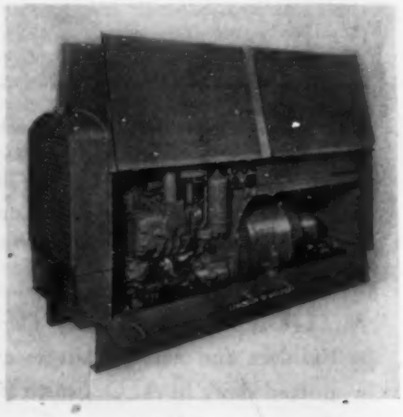
apparatus efficiency. Reactors and transformers are of dry type construction. No moving parts; small in size; can be installed in almost any desired location. No fireproof enclosures necessary. Requires no discharge coils or other safety devices. Made under A.I.E.E. specifications and N.E.M.A. standards.

NEW DIESEL-DRIVEN WELDER

A new Diesel engine driven welder of 300 amp. capacity specially made for use in locations where electric power is not available, or not economical, is announced by The Lincoln Electric Co., Cleveland, Ohio.

Powered by a two-cycle Diesel engine, this addition to the Lincoln "Shield-Arc" welder line cuts fuel costs up to 86%, depending upon the price of fuel oil used. In many cases, total savings, including such items as transportation of fuel, losses, etc. are as high as 40% per hour.

The welding generator has N.E.M.A. rating, 300 amp. at 40 v. Current range for welding duty is from 20 to 40 v., 60 to 375 amp. Single-operator variable voltage type, with complete laminated magnetic circuit (frame and pole pieces) and equipped with interpoles. Requires no external reactance of stabilizer. Patented dual control of welding current is accomplished by adjustment of both series and shunt fields. Supplies uniform welding current for metallic arc welding in any position with bare or heavily coated electrodes, also for carbon arc welding.



The generator frame is attached to the Diesel engine bell housing and the generator shaft is connected to the engine flywheel by a special type of flexible coupling. The entire unit is mounted in a substantial channel frame. A sturdy metal grille protects the radiator front.

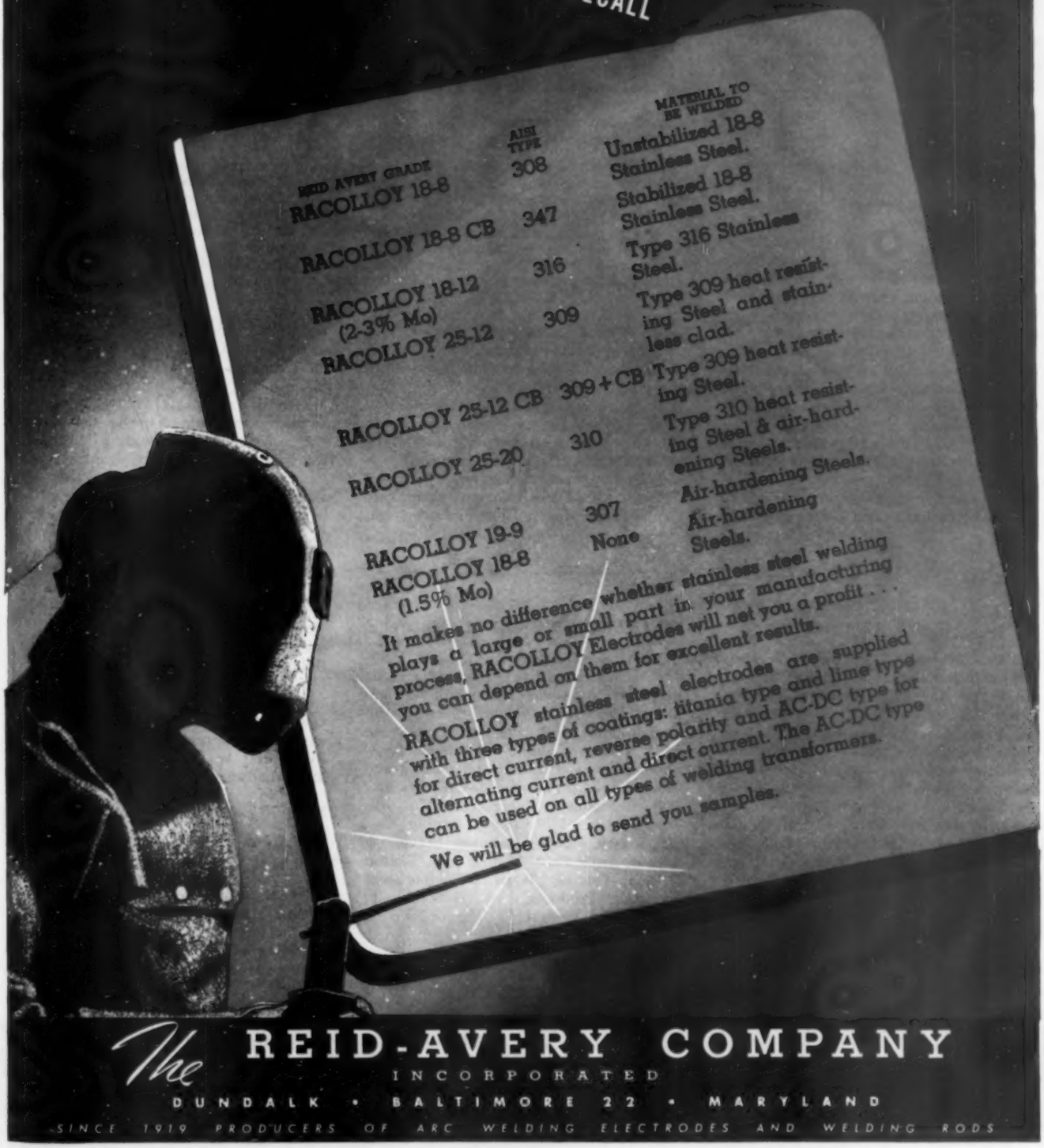
The new "Shield-Arc," 300-amp. welder (stationary model) weighs 2560 lb. and can be readily mounted on wheels, trailer or truck for easy portability. Optional equipment includes spring-mounted running gear of automobile trailer type with four wheel pneumatic tires.

NEW ULTRA-SPEED WELDING UNIT TO REDUCE ASSEMBLY TIME

A new ultra-speed welder control unit, designed and built by Progressive Welder Co., 3050 E. Outer Drive, Detroit 12, Mich., now permits automatic assembly welding rates up to 900 spots per minute. Designed to meet the increased demand for fully automatic multiple-spot resistance welding machines capable of producing a large number of joints quickly and in one operation, this new machine control

racolloy electrodes

ANSWER THE STAINLESS STEEL ROLLCALL



REID AVERY GRADE	AISI TYPE	MATERIAL TO BE WELDED
RACOLLOY 18-8	308	Unstabilized 18-8 Stainless Steel.
RACOLLOY 18-8 CB	347	Stabilized 18-8 Stainless Steel.
RACOLLOY 18-12 (2-3% Mo)	316	Type 316 Stainless Steel.
RACOLLOY 25-12	309	Type 309 heat resisting Steel and stainless clad.
RACOLLOY 25-12 CB	309+CB	Type 309 heat resisting Steel.
RACOLLOY 25-20	310	Type 310 heat resisting Steel & air-hardening Steels.
RACOLLOY 19-9	307	Air-hardening Steels.
RACOLLOY 18-8 (1.5% Mo)	None	Air-hardening Steels.

It makes no difference whether stainless steel welding plays a large or small part in your manufacturing process, RACOLLOY Electrodes will net you a profit . . . you can depend on them for excellent results.

RACOLLOY stainless steel electrodes are supplied with three types of coatings: titania type and lime type for direct current, reverse polarity and AC-DC type for alternating current and direct current. The AC-DC type can be used on all types of welding transformers.

We will be glad to send you samples.

The REID-AVERY COMPANY
INCORPORATED
DUNDALK • BALTIMORE 22 • MARYLAND
SINCE 1919 PRODUCERS OF ARC WELDING ELECTRODES AND WELDING RODS

Fig. 1—This New Progressive Control Unit Is the Heart of the Company's New Ultra-Speed Automatic Multiple Spot Welding Machines

It dispatches individually timed welding current to from 10 to 100 or more guns, each adjusted to its own proper welding pressure. Welding rates up to 900 spots per minute are possible to speed the assembly of complicated parts in a single setup.

has reduced the practical production limitations of such machines to the time required to load and unload the parts.

The Progressive ultra-speed unit is the heart of all new Progressive ultra-speed welding machines, directing the "program" of all such automatic multiple spot welders. It distributes welding current to a single or to groups of welding points successively by means of a screw driven carriage that depresses push rods to engage contacts much in the same manner as one would run a finger over a piano keyboard. At the same time another element of the carriage engages adjustable stroke plungers to control individually the length of time the welding current flows for each weld. All welding points bear on the work simultaneously under welding pressure before the first weld is formed and remain until the last weld is completed, eliminating the separate "squeeze" and "hold" times usually required for each weld. Thus 20, 50, 100 or more joints can be made in slightly more time than the total of the individual "weld times"—at a few hundredths of a second each.

Ultra-speed controlled machines can be built to accommodate an almost unlimited

Fig. 2—Typical Progressive Welder Co. Ultra-Speed Machine (Used for the Automatic Assembly Welding of Psychopathic Ward Cell Panels of Various Lengths)

Integral loading and clamping fixture mounted on horizontal carriage is moved into the machine by hydraulic motor at high speed, automatically slows down and stops at first welding position within a tolerance of $^{10}/_{1000}$ in. The guns come down and 40 series welds are produced in the 16-gage steel. The guns raise while the carriage moves to the next weld position and the ultra-speed control unit returns to start position. The cycle is repeated until the required number double rows of welds have completed the assembly. The carriage moves through the machine to unload the assembly at the rear. Total time for the welding of each group of 40 welds is only 15 sec.

range of weld spacings and locations such as are required by automotive, refrigerator, stove, etc., subassemblies (sometimes composed of many parts). The welding guns can be arranged in single or multiple rows, circles, steps, curves, etc., either closely spaced or spanning the full width of large panels. Individual timing of each welding gun permits the spot welding of different thicknesses of metals during one complete operation. Thus reinforcing sections, brackets, spacers and trim forms can be joined to a main panel using the most suitable type and thickness of metal for each.

Provision of integral clamping positions at the proper locations in the machine plus the positive action of welding guns applying pressure on the work simultaneously, results in a finish-forming action that automatically compensates for variations in the component parts.

FLASH WELDERS

A striking 8-page, 2-color, technical and descriptive bulletin describing the unusual new line of Progressive Standard Flash Welders has just been released by the Progressive Welder Co., 3050 East Outer Drive, Detroit 12, Mich. Phantom and detail views are used to illustrate the numerous exclusive features—including the "unit" construction which characterizes all models, from 20 to 250 kva.—which make the line of machines adaptable to a wide range of flash and butt welding applications.

Choice of manual, semiautomatic or full automatic control is available for either air or hydraulic clamping or mechanical or hydraulic upset operation. Full hydraulic operated models are designed to permit the operator to intercede at any point in the automatic welding cycle and take over the control.

Large universal platens permit the mounting of either horizontal or vertical clamping fixtures, as required, to accommodate extruded sections, strip stock, tubing, forgings, ring sections, bar stock, etc., for greatest ease of handling.

NEW METAL & THERMIT DISTRIBUTORS

Metal & Thermit Corp., New York, N. Y., announces the appointment of six new distributors who will handle its complete line of Murex welding electrodes including mild steel, alloy steel, stainless, hard surfacing, aluminum bronze, phosphor bronze and underwater cutting and welding rods. The new distributors are: Hill Equipment Engineering Co., St. Louis, Mo.; Mid-County Supply Co., Stephenson, Mich.; Johnson Service & Supply, Little Falls, Minn.; J. T. Shelton & Son, Odessa, Texas; Welding and Industrial Products, Ltd., Honolulu, T. H.; and José Cestero, Jr., Puerto Rico.

SOUND-COLOR FILM

"Mass Production of Massive Parts" is the title of a new 16-mm. sound and color motion picture just completed for Metal & Thermit Corp. The new film portrays the possibilities of fabricating very heavy parts for equipment of all kinds by means of Thermit welding and shows the methods employed during the war by The California Shipbuilding Co. in building thousands of 40-ton stern frames for cargo ships. Prints are available without charge for showing to local sections of engineering and technical societies, as well as interested industrial concerns, by request to Metal & Thermit Corp., 120 Broadway, New York 5, N. Y.

R.W.M.A. ELECTS NEW OFFICERS

At the regular meeting of the Resistance Welder Manufacturers' Association, which was held in Detroit on January 24th, the following officers were elected to serve during 1946:

President, Mr. H. B. Warren, Executive Vice-President, Thomson-Gibb Electric Welding Co., Lynn, Mass.; *Vice-President*, Mr. G. N. Sieger, President and General Manager of S-M-S Corporation, Detroit, Mich.; *Executive Secretary*, Mr. George A. Fernley, Philadelphia, Pa.; *Secretary-Treasurer*, Mr. H. R. Rinehart, Philadelphia, Pa.

Aluminum Spot Welds Per Coach Prove Value of Federal Welders...

The generous capacity, passenger comfort and strength built into modern aluminum coaches by the ACF Brill Motors Company of Philadelphia call for the ultimate in aluminum fabrication. Naturally, resistance welding is specified for a large share of the work. 9,000 aluminum spot welds are required to make a single body. They must be absolutely failure-proof, and, as assembly components are large and costly; the quality of each individual weld must be certain. The newest of the many Federal Resistance Welders installed in the Brill plant is a three-phase condenser discharge stored energy spot welder, with 84" Throat Depth . . . the largest of its kind ever made. It was installed because of the results achieved with a previous 54" Federal, which it now supplements in daily production. Full extra length doors, full side and end panels, as well as a great many smaller pieces are handled on the big machine. Federal Engineers developed a design so rigid that despite its "reach" deflection is less than on smaller welders. The special requirements of aluminum welding, exactitude of pressure and fast positive follow-up, are achieved so well that rejections are held to a minimum. This is typical of fabrication with Federal Resistance Welders, whether it be spot, projection, flash, butt, seam or "gun" welding. In every branch of the modern metal working field, this sort of efficient production of quality goods is proving that . . . in resistance welding, the name of authority is

Federal

AND WELDER COMPANY

206 DANA STREET • WARREN, OHIO

ABSTRACTS OF CURRENT WELDING PATENTS

Prepared by V. L. Oldham

Printed copies of patents may be obtained for 10¢ from the Commissioner of Patents, Washington 25, D. C.

2,391,565—WELDER'S MASK; Thomas H. Grindrod and Arthur E. Church, *Inventors;* Portland, Ore. *1 claim.*

This patent covers a mask for covering the nose and mouth of the wearer and contacting the wearer's cheeks. The cheek contacting edges of the mask are fluted to permit outward flow of air, while means for injecting fresh air along the front of the mask also are provided.

2,391,762—WORK HOLDER FOR ARC-WELDING APPARATUS; John Raymond Wirt, *Inventor;* Anderson, Ind. Assignor to General Motors Corp. (*3 claims*).

The work holder has means for moving work holders in end-to-end relation along a guiding track past an arc-welding electrode and such means include a work support having track-engaging provisions. A block of metal of high thermal and electrical conductivity is attached to the work support and adapted to extend into the space between work pieces on adjacent work holders when on the track. The metal block also has a portion adjacent to the end of the work piece to provide an arc-contacting surface spaced from the electrode at a distance greater than the gap between the electrode and the work.

2,391,934—BURNER TIP; Samuel H. White, *Inventor;* Lakewood, O. *3 claims.*

The tip includes a casing, and a tip with the flame end of the tip being coincident with the flame end of the casing. The tip has longitudinally ranging channels, having a width of 0.01 in. and a depth of at least 0.025 in., formed therein.

2,391,940—STORING AND TREATING STRUCTURE FOR WELDING ELECTRODES; George M. Beimer, *Inventor;* Rutherford, N. J. Assignor to Couse Laboratories, Newark, N. J. *2 claims.*

The structure patented is for use with a vehicle repair shop and includes a cabinet having means for positioning electrodes, and a heat transferring chamber associated with the cabinet adjacent the electrode positioning means. Heat from the engine of the vehicle is led to and from the heat transfer chamber.

2,392,101—CONTROL OF WELDING CURRENT; Robert Lee Ringer, Jr., *Inventor;* Warren, O. Assignor to The Taylor-Winfield Corp., Warren, Ohio. *11 claims.*

The invention is for use in a welding system having a periodic current source and a welding transformer having its secondary winding connected to the electrodes. The control of the effective current translated by the transformer has means for inducing a variable flux therein having a wave form substantially coincident with the voltage wave form of the periodic current source, and means to suppress the peaks of the flux by inducing in the transformer a variable flux of substantially equal periodicity with the first-mentioned flux but in opposition thereto. Further means are provided to vary the magnitude of the second-mentioned flux.

2,392,281—METHOD OF MAKING WELDED BLADE STRUCTURES; Robert C. Allen, *Inventor;* Wauwatosa, Wis. Assignor to Allis-Chalmers Manufacturing Co., Milwaukee, Wis. *5 claims.*

The welding method relates to the manufacture of bladed elements for turbines and the like and includes the steps of placing a chill ring over a portion of the hub member, abutting a portion of the base of a blade on the chill ring, and fusing metal to the hub and base. Then the chill ring is removed and the remainder of the base of the blade is fused to the hub by metal introduced therebetween.

2,392,296—ACTUATING SYSTEM FOR WELDING ELECTRODES AND THE LIKE; Melvin M. Seeloff; *Inventor;* Warren, Ohio. Assignor to The Taylor-Winfield Corp., Warren, O. *5 claims.*

This apparatus includes a hydraulic fluid motor connected with an electrode for moving it toward its cooperating electrode and hydraulic fluid is supplied to such motor so as to move the electrode and set up a welding pressure thereby. Fluid discharge means are present in the supply line for the motor and are normally open so that when quickly closed by means provided for such action, the kinetic energy of fluid moving in the motor supply line is translated into a pressure surge in the motor to increase the pressure exerted by the electrode moved thereby.

2,392,353—FLUX-FORMING FUEL, AND METHOD FOR THERMALLY WORKING MINERALS THEREWITH; Robert B. Aitchison, *Inventor;* Grasmere, N.Y. Assignor to The Linde Air Products Co. *6 claims.*

The patent relates to a process for thermally working minerals wherein an oxy-fuel flame is applied to a portion of the mineral and a flux forming fuel is introduced into the flame. The feature of the patent relates to the use of a comminuted, unbonded mixture, of a minor part, by weight, of pulverulent zirconium-silicon alloy, the remainder being substantially all pulverulent iron, which mixture is introduced into the flame as a flowing stream. The alloy comprises by weight 10 to 50% zirconium and 30 to 60% silicon with any remainder being substantially all iron.

2,392,386 and 2,392,593—TORCH TIP; both patents to Alexander F. Jenkins, *Inventor;* Baltimore, Md. Assignor to The Alexander Milburn Co., Baltimore, Md. *5 and 7 claims, respectively.*

The patented torch tip has a main body portion provided with an axial oxygen passageway, and an annular series of combustion gas passageways opening through discharge orifices in the front end of the tip. An annular recess is formed in the rear end of the body portion and the gas passageways lead from the recess. The rear of the body receives an annular member that has a series of gas admission passageways that discharge into the annual recess so as to equalize the gas flow through the passageways in the body.

2,392,736—WELDING ELECTRODE COOLING; Franz R. Hensel and Earl I. Larsen, *Inventors;* Indianapolis, Ind. Assignors to P. R. Mallory & Co., Inc., Indianapolis, Ind. *7 claims.*

In this device, the electrode is used to exert pressure and has depressed portions in its outer surface. A sleeve covers the outer ends of such depressed portions to define a cooling space, and means are provided to pass cooling fluid through such space.

2,392,824—PRESSURE WELDING PROCESS AND APPARATUS; Arthur R. Lytle and William Morton, *Inventors;* Niagara Falls, N. Y. Assignors, by mesne assignments, to The Linde Air Products Co., a corporation of Ohio. *20 claims.*

The patent process is for butt welding tubular members having different wall thicknesses. The members are longitudinally aligned with their ends in an abutting relation and are forced together while a group of welding flames encircling the members is played on the greater thickness member adjacent to its end. The flames are reciprocated across the interface formed by the abutting ends along selected patterns of fixed length, and after the metal of the member of greater wall thickness has reached a dull red heat but before substantial upsetting of metal occurs, the centers of reciprocation of the groups of flames are shifted toward the interface between the abutting ends to equalize the temperature of the members. Thereafter the end portions of the members are upset and shortened.

2,392,879—ELECTRODE MANUFACTURE; Thomas J. Radcliffe, *Inventor;* Belleville, N. J. Assignor to General Electric Co., a corporation of New York. *1 claim.*

In this patent, a method of manufacturing concave cold types of electrodes having a metallic coating on their inner surfaces is disclosed. The method includes coating one side of a metal strip with a suspension of a powdered anti-glow metallic material in a volatilizable binder, and baking the coating at a temperature too low to impair the ductility of the metal strip. Then the concave electrodes are formed and punched from the metal strip with the coated side forming the inner surface of the electrode which thereafter is fired at a temperature high enough to drive off the binder and leave an adherent coating of the metallic material on the inner surface of the electrodes.

2,392,886—METHOD OF COPPER BRAZING;

HOW MUCH WELDING RESEARCH IN A BAG?...A TON?...A CARLOAD?

There was a time, we're told, when electrodes were the product of a "back yard clay pile and a few lengths of iron wire." This day of simplicity has gone.

From our corner of the welding business, for example, we supply alloying and slag forming materials, arc stabilizers, binders, fluxes, organics, scavengers, and slipping agents . . . and from one to two dozen products in each classification. We're mighty fussy about quality. Our laboratories hum with control analyses of all shipments.

Welding with experimental rods in Foote Laboratory

Equally important to you . . . our researchers are continually "scouting" for new material resources, developing new products and processes, improving old ones.

Extruding experimental rods in Foote Welding Laboratory

In our lab, we have heavy duty extrusion and slugging presses and mixers, drying ovens, strength and hardness testers, welders . . . and men who know how to use them.

Whether you buy a bag, a ton, or a carload of Foote welding rod coating materials, you get a full measure of technical advancement.

HAVE YOU THIS NEW BOOKLET? — "Welding Rod Coating Ingredients" describes materials, services, and publications available from us. Send request on your letterhead.

Foote
MINERAL COMPANY
A Step Ahead in Industrial Ores and Chemicals

Chemicals • Ores • Metals • Alloys

PHILADELPHIA • ASBESTOS • EXTON, PENNSYLVANIA

Home Office: 511 GERMANTOWN TRUST COMPANY BLDG., PHILA. 44, PA.
West Coast Representative: Griffin Chemical Co., San Francisco, Cal.

Henry D. Steecher, Lakewood, and Joseph Norman Paquin, Euclid, Ohio, *Inventors*. Assignors to The Weatherhead Co., Cleveland, Ohio. *3 claims.*

The patent covers a method of securing fine mesh metallic screen within a copper brazed assembly while preventing copper from reaching the material of the screen. In the patent, the method disclosed includes the steps of binding the edges of the screened material with a chromium-plated strip of ferrous material, removing the chromium plating from the peripheral portion of the ferrous material, assembling the screen with another ferrous member having a portion engaging the peripheral portion of the first ferrous material and supplying copper adjacent the contacting surfaces of the part. The assembly is then passed through a brazing furnace to fuse the copper and form a bond between the peripheral edge and the adjacent ferrous parts. The chromium plating prevents the molten copper from flowing over the ferrous binding and on to the screen during the brazing operation.

2,393,198—WELDING APPARATUS; Gareth G. Somerville, *Inventor;* Pittsfield, Mass. Assignor to General Electric Co. *11 claims.*

Somerville's welding apparatus includes a rigid support, a rigid beam extending across the support and a flexible jaw member between the beam and the support. Further means, such as spring members located lengthwise of and between the beam and jaw member transmit clamping pressure from the beam to the jaw member. The pressure transmitted by each of the springs may be adjusted while means for moving the beam and rigid support relatively of one another are also provided.

2,393,199—WELDING APPARATUS; Gareth G. Somerville, *Inventor;* Pittsfield, Mass. Assignor to General Electric Co. *5 claims.*

This patent relates to a welding torch wherein an electrode holding collet is seated in an electrode holder and electrode adjusting screws are associated with the mechanism. One of the adjusting screws makes a threaded engagement with the holder and acts on the collet while means for rotating such screw to effect lengthwise movement of the electrode are also provided.

2,393,459—ELECTRODE; William W. Eitel, San Bruno, and Jack A. McCullough, Milbrae, Calif., *Inventors*. Assignors to Eitel-McCullough, Inc., San Bruno, Calif. *1 claim.*

The electrode disclosed by this patent has a tubular body made from flanged arcuate sections secured together along the flanges. The flange on one of the sections has a portion projecting beyond the edge of an adjacent flange of another section with this projecting portion lying in a plane parallel with such adjacent flange.

SECTION ACTIVITIES

CHATTANOOGA

The January meeting of the Chattanooga Section was held on the 10th at the Chattanooga Golf and Country Club. E. H. Turnock, manager of the Welding Electrode Division, Westinghouse Electric Corp., talked on the subject "Welding Electrodes."

Mr. Turnock presented a brief history of welding electrodes and explained the A.W.S. classification numbering system in a very interesting manner.

The talk was preceded by a dinner with 25 members and guests present.

The February meeting was held on the 1st, at the Chattanooga Golf and Country Club. D. H. Corey, welding engineer for The Detroit Edison Co., spoke on "Welding of High-Pressure, High-Temperature Piping."

The talk was clearly illustrated by slides and included a number of practical suggestions as to the equipment, design and technique which, if properly used and applied, will produce high-quality welds.

The meeting was preceded by a dinner with 32 members and guests present.

CHICAGO

"Ideas on Arc Welding" was the subject of the January 18th meeting held at People's Gas Light and Coke Co. Auditorium. Carl M. Underwood, manager, Welding Dept., Northern Ordnance, Inc., Minneapolis, discussed arc-welding practices, paying particular attention to the activities of his company during the war. Northern Ordnance was one of the largest manufacturers of Naval Ordnance gun mounts during the past four years. In addition, they produced rockets and many other welded war materials.

Premeeting movies were shown as follows: "Wheels Across Africa" shown through the courtesy of the Dodge Corp. and "Big League Baseball" shown through the courtesy of the Official Baseball Organization.

CINCINNATI

The regular monthly meeting of the Cincinnati Section was held on January 29th at the Engineers' Club.

Walter J. Brooking, director of tests and research, The R. G. LeTourneau Co., Peoria, Ill., had as his topic "Economics of Arc Welding" which he presented to a large audience. Mr. Brooking also showed along with his talk, a sound picture and illustrated slides.

The following night, January 30th, Mr. Brooking presented the same program before the newly organized Dayton Section at the Engineers' Club of that city before a large turnout.

CLEVELAND

E. B. Williams, vice-president in charge of Engineering for the American Ship Building Co., spoke on January 9th on "The War's Welding Lessons in Shipbuilding." Mr. Williams' analysis of the techniques and methods for welding large structures was extremely interesting, and indicated just how far welding has developed from a production sense in the last five years.

As dinner speaker, A. G. Hopcraft, director of purchases for the Cleveland Worm and Gear Co., spoke on "Humor in Buying and Selling." Mr. Hopcraft told the greatest variety of jokes ever to shake down a Cleveland Section dinner, and was a big success. Mr. Hopcraft has been active in purchasing work in Cleveland for 36 years, both in private industry and for the City of Cleveland, and was a former president of the National Association of Purchasing Agents.

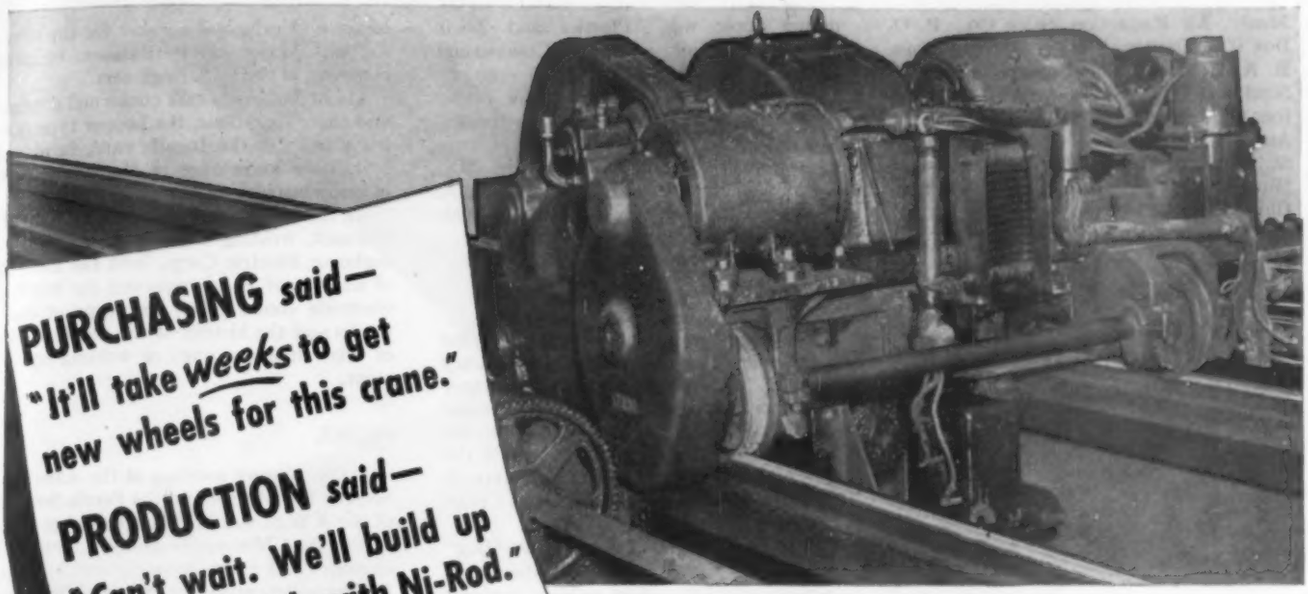
The educational course of the Cleveland Section has been progressing very satisfactorily. On January 14th a meeting on Nondestructive Tests was held by the Herron Testing Co.; on January 21st, Cecil C. Peck discussed Jigs and Fixtures for Welding; on January 28th the educational group made a plant visitation to the electrode plant of Whitey Maurath.

COLUMBUS

The February 8th meeting held at the Southern Hotel was sponsored by The Seagrave Corp. Dinner speakers were H. M. Havens, chief engineer, Seagrave Corp., and Floyd Pfaltzgraft, Battalion Chief, Columbus Fire Dept. Technical speaker was G. N. Sieger of the S-M-S Corp., Detroit, Mich. Mr. Sieger's subject "Resistance Welding" was well received.

DAYTON

A newly organized Section has been formed in Dayton, Ohio. Officers of this Section are as follows: *Chairman*, A. J.



PURCHASING said—
"It'll take *weeks* to get new wheels for this crane."

PRODUCTION said—
"Can't wait. We'll build up the worn treads with Ni-Rod."

This overhead crane was being used in a foundry.

Running *sideways* on the wheels and rails shown, the whole unit (crane and rails) also travels *lengthwise*, rolling on rails atop two side walls.

Normally, there is a ½" clearance between wall rails and the I-beams supporting the cross-carriage. However, as the cast iron wheels wore down, the clearance gradually disappeared until binding of the beam on the rail threatened to derail the unit.

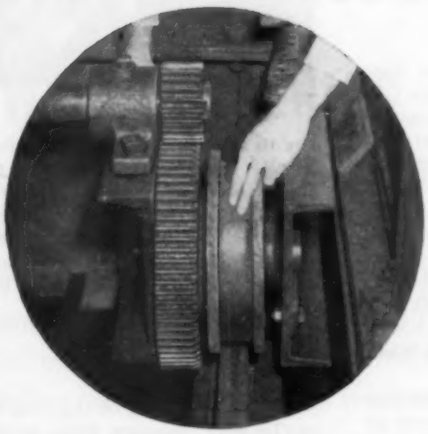
Operation of the crane had to cease. With new wheels unavailable for several weeks, the foundry was in a jam.

But new wheels were not needed!

Instead, the "super" ordered the worn treads built up with Ni-Rod.

Only 4 days were lost . . . 1 day for removing, welding, machining and replacing each wheel.

There was no preheating, just a simple preliminary cleaning. And, the deposit was easy to grind down. Ni-Rod deposits are *always* easy to grind, file or machine.



CLOSE-UP *shows welded wheel, ground down to desired diameter. The overlay of Ni-Rod was deposited in successive layers until 1" was added to the wheel diameter. After each layer, the slag was removed by wire brushing. About 8 lb. of ⅛" rod was used per wheel. Total load on wheels is 8 tons.*

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Extremely useful for general maintenance work, NI-ROD is a real saver of time and money. Use Ni-Rod for on-the-spot repairing of broken or worn castings . . . for remedying casting defects in the foundry . . . and for any welding job on cast iron where strong, sound and machinable welds are essential.

Order a 5-lb. package, and see for yourself how easy it is to get good welds with Ni-Rod. Works on a.c. or d.c. Instruction booklet is available.

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DETROIT

The fifth meeting of the season of the Detroit Section and Saginaw Valley Division were held on January 10th and 11th, respectively. Lightweight metals was the subject for both meetings. L. J. Benson, chief metallurgist, Parts Division, Reynolds Metals Co., spoke on "Welding and Brazing Aluminum." It was noted that 12½-lb. wheelbarrows, 16½-ft., 60-lb. canoes have been produced or are ready for production, as are lightweight typewriters and outboard motors. Plans for an all-aluminum 7780-ton seagoing vessel are on the boards and other vessels having a superstructure of lightweight metal are planned for the near future.

HARTFORD

On January 17th the Hartford Section was addressed by J. R. Craig of The Linde Air Products Co. Mr. Craig explained that his subject, "Heliarc Welding" was so new that no slides or motion pictures were available with up-to-date information. However, he gave the Section a very good description of the methods involved and the equipment available for this type of work.

LEHIGH VALLEY

The regular monthly meeting of the Lehigh Valley Section was held on February 4th, at the Hotel Bethlehem, Bethlehem, Pa.

After the dinner, the Reid-Avery Co.'s high-speed film showing the Characteristics of the Welding Arc was shown.

Chairman Kenworthy introduced the speaker of the evening, A. A. Holzbaur, asst. welding engineer and welding foreman with the Sun Shipbuilding and Drydock Co., who gave an illustrated talk on "Low-Temperature Stress Relief." Mr. Holzbaur pointed out that by proper application of heat and water, the maximum residual stresses in welded plate joints have been greatly reduced.

MARYLAND

The January meeting of the Maryland Section was held on the 18th. Dinner at the Engineers Club preceded the meeting. J. H. Cooper of the Taylor-Winfield Corp. presented a good, clear-cut and interesting talk on "Resistance Welding Applications," which was illustrated with slides. The meeting dealt with resistance welding developments during the war. The speaker showed how many production bottlenecks were broken in war materials by resistance welding.

MILWAUKEE

Regular meeting was held on January 25th at the Ambassador Hotel. After-dinner topic was "Plastics and Their Uses in the Industrial and Commercial Field."

Welding Address was made by James W. Owens, director of welding, Fairbanks, Morse & Co., Beloit, Wis. Mr. Owens spoke on "Routine Inspection of Machinery Weldments and Their Salvage by Precision Welding," a subject on which he has had a great deal of experience.

NEW JERSEY

The regular monthly meeting of the New Jersey Section was held on January 15th at Essex House, Newark. Dinner preceded the meeting. As is the usual practice, an "Information Please" session was held preceding the main talk of the evening. Charles Cooper of the Metal & Thermit Corp., New York, acted as Chairman of this session.

"Process Control of Aircraft Welding" was presented by Paul H. Merriman, chief electrical and chief welding engineer of The Glenn L. Martin Co., Baltimore, Md. The talk discussed the use of various welding processes used in the aircraft industry, and was illustrated with slides and a motion picture. It also covered building some of the planes, both those built during the war and those that are being built for postwar service.

NEW ORLEANS

A very successful meeting of the New Orleans Section was held on January 7th. Joining in the attendance were about 20 members of the American Society of Tool Engineers of New Orleans, and altogether, about 85 people attended the meeting.

In the absence of C. H. Jennings of the Westinghouse Electric Corp., who was scheduled to talk on welding distortion, but was unable to be present, a talk was given by E. H. Turnock of Westinghouse, who spoke on the subject "Welding Electrodes."

About 90 attended a very fine meeting held on January 30th. D. H. Corey of the Detroit Edison Co. presented a very interesting talk.

NEW YORK

The regular monthly meeting of the New York Section was held on January 8th in the Engineering Societies Building. Dinner at the Engineers Club preceded the meeting.

The technical session had as its speaker Bela Ronay, principal welding engineer, U. S. Naval Engineering Station, Annapolis. Mr. Ronay's subject was on "The Navy—E.E.S. Method for Determining the Applicable Welding Procedure for Steel." Mr. Ronay's subject provided a means of determining the optimum conditions for welding the so-called "hard to weld" or "nonweldable" grades of steel.

PASCAGOULA

An interesting meeting was held on the evening of February 12th at the Pascagoula Country Club. The guest of honor and principal speaker for the evening was Major M. F. Balance, resident engineer, of the U. S. Engineers.

Major Balance's talk concerned dredges and their operations, the hopper type now being built in the Ingalls yard, furnished invaluable knowledge of this new phase of ship construction.

At the meeting on January 8th, E. H. Turnock, welding engineer for the Westinghouse Electric Corp., held the interest of all present as he explained the welding electrode conservation and type of electrodes and the history of the development of this important piece of welding equipment.

PEORIA

A joint dinner meeting of the American Society for Metals and the Peoria Section of the A.W.S. was held on December 19th at the Pere Marquette Hotel. Over 300 members and guests were present. Louis B. Neumiller, president, Caterpillar Tractor Co., spoke on "Costs and the Future." Mr. Neumiller said that production is the

key to a continued rise in the standard of living. "A company by aid of good machine tools and other productive equipment can cut the cost of its product, then can offer that product at a lower price," said Mr. Neumiller. Selection and training of employees is another important factor, it was pointed out.

PUGET SOUND

The first meeting of the year was held on Tuesday, January 22nd, at the Engineers Club.

After dinner a talk was given by Joe Holt on directional welding and heating to avoid distortion and weld failures. In his speech Mr. Holt brought out the basic underlying facts regarding weld stresses and proved his point by means of diagrams and actual slides.

An A. O. Smith talking picture showing the manufacture of pipe concluded the evening's meeting.

ROCHESTER

The Annual Bowling Party was held by the Rochester Section at Ridge Hall on Saturday Night, January 26th. Door prize and score prize were awarded.

The regular monthly meeting was held on February 7th at the Lower Strong Auditorium, University of Rochester, River Campus. Dinner at the Powers Hotel preceded the meeting. The speaker was Earl M. Schaub of the Arcos Corp., Philadelphia. His subject was on "Arc Welding of Stainless Alloys." A movie "Wealth of the Andes" was also shown.

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SAINT LOUIS

January meeting of the St. Louis Section was held on the 11th at the Hotel Melbourne. Dinner as usual preceded the technical session.

"Steel Castings—Their Use in Weldments" was presented by E. J. Wellauer, supervisor research and metallurgy, The Falk Corp., Milwaukee. The subject was very well presented and enthusiastically received.

After the formalities, light refreshments were served, during which there were informal discussions of the evening's subject matter.

SAN FRANCISCO

Leo Berner, manager and chief engineer, Leo Berner Engineering Co., San Jose, was the guest speaker at the January 28th meeting. Mr. Berner's talk "Welding a 500-hp. Diesel Engine" was fully illustrated with slides and described in considerable detail the design and fabrication of the welded block and base of the Hendy Diesel engine.

Two sound films were shown through the courtesy of the British Information Services. The first "Bailey Bridge" revealed one of the war's most jealously guarded secrets, the construction and use of a portable, prefabricated bridge made of interchangeable parts. The second film "Time and Tide," showed the important and little-known work of the men of the Admiralty Salvage Department as they clear a harbor of wrecked enemy vessels.

SOUTH TEXAS

James F. Lincoln, president of The Lincoln Electric Co., addressed members of the South Texas Section at a dinner meeting in Houston on January 18th and discussed the "Future of Welding in Industry." Mr. Lincoln prefaced his remarks on welding with a brief discussion of the slow procedure by which human opinions and conceptions change through the years, and cited the sudden and quite recent changes in our thinking in terms of atomic energy.

WASHINGTON

The Washington Section held its January meeting on the 29th in the Potomac Electric Auditorium, with Charles W. Briggs, technical and research director, Steel Founders Society of America, as the speaker of the evening.

Mr. Briggs' topic, "Welding in the Steel Foundry," was responsible for bringing out not only the usual regular attendants, but also a large number of local foundrymen. He discussed the two major applications of welding within the steel casting industry. To conclude his talk, Mr. Briggs described the conditions he found in Germany last summer in his tour of inspection of German foundries.

WICHITA

The Wichita Section held a joint meeting with the American Society for Metals on January 15th in the Aeronautical Room of the Alice Hotel.

The speaker of the evening was R. G. McElwee of the Vanadium Corp. of America. Mr. McElwee is manager of the iron foundry division of his company. "Foundry Practices" was the speaker's subject. Mr. McElwee stressed the importance of flame hardening of castings and the importance of correct addition of alloys to iron.

YORK-CENTRAL PENNSYLVANIA

Regular monthly meeting was held on February 6th in the Engineering Building, York. Dinner at Yorktowne Coffee Shop preceded the meeting.

R. M. Dennis, assistant to president, By-Products Steel Corp., Division of Lukens Steel Co., addressed the meeting on "Forming and Bending Metals." Mr. Dennis gave a brief history of the By-Products Steel Corp. and described some of the processes and problems involved in the forming of steel plate shapes. His talk was illustrated.

List of New Members

January 1 to January 31, 1946

BOSTON

Curley, David C. (C), 51 Norfolk St., Suite 6, Cambridge 39, Mass.
Herman, Earl L. (B), 27 Stellman Rd., Roslindale, Mass.
Lockwood, Aaron L. (B), Harnischfeger Corp., 526 Statler Bldg., Boston, Mass.
Lorente, Mariano Joaquin (C), 25 Tavern Rd., Boston 15, Mass.
Wilinski, Marceli K. (B), Monsanto Chemical Co., Chemical Lane, Everett 49, Mass.

BRIDGEPORT

Johnson, Samuel (C), 146 Hilltop Dr., Nichols, Conn.
Sullivan, Edward L. (C), 1139 Noble Ave., Bridgeport 8, Conn.

CHICAGO

Allen, Joseph H., Jr. (C), *The Welding Engineer*, 520 N. Michigan Ave., Chicago 11, Ill.
Horan, Bart J. (C), 7737 Essex Ave., Chicago, Ill.
Murray, Charles H. (C), North Side Welding Supply Co., 2049 Belmont Ave., Chicago, Ill.
Perry, Peter M. (C), 5728 N. Campbell Ave., Chicago 45, Ill.

CINCINNATI

Keith, Thomas H. (B), P. O. Box, Lockland, Cincinnati 15, Ohio.
Kelm, George E. (B), P. O. Box 26, Lockland, Cincinnati 15, Ohio.
Skelly, John X. (B), P. O. Box 26, Lockland, Cincinnati 15, Ohio.

CLEVELAND

Dragony, Ernest J. (C), 2119 W. 61st St., Cleveland, Ohio.
Grehore, David R. (C), 2800 Cleveland Blvd., Lorain, Ohio.
Hillen, Harvey J. (C), Route 1, Macedonia, Ohio.
Horrigan, V. J. (C), 18740 Shaker Blvd., Shaker Hts., Ohio.
Johnson, Mahlon L. (C), 26230 Zeman Ave., Euclid, Ohio.
Kemp, John C. (C), Ampco Metal, Inc., Room 506, United Office Bldg., 25th & Lorain, Cleveland 13, Ohio.
Pavlicek, Frank (C), 3363 Warrensville Center Rd., Shaker Hts., Ohio.
Schroeder, Carl J. (C), 20675 Almar Dr., Cleveland 22, Ohio.

COLUMBUS

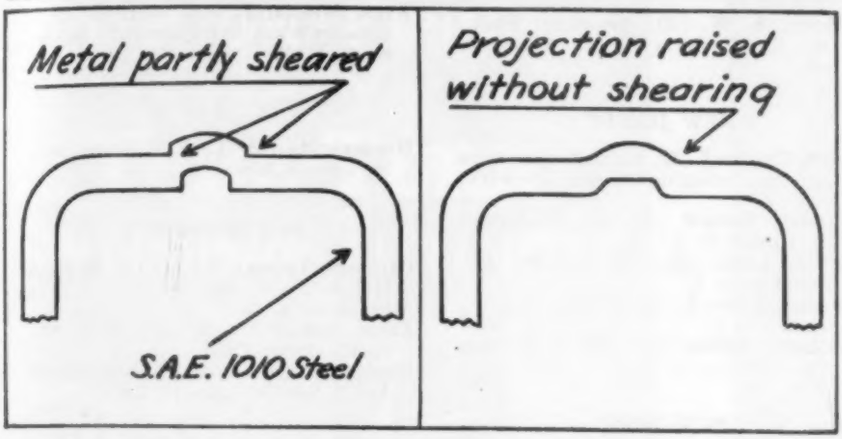
Olson, B. C. (C), 879 Vernon Rd., Columbus 9, Ohio.
Reed, Earl B. (C), 1389 Genesee St., Columbus, Ohio.
Smith, Oren R. (C), 1474 Stelzer Rd., Columbus, Ohio.

DAYTON

Clark, Oscar L. (B), 1039 W. Dorothy Lane, Dayton 9, Ohio.
Clemens, Clarence F. (B), 1619 McLain St., Dayton, Ohio.
Fogarty, Will J. (C), Fogarty Mfg. Co., 1090 E. Monument Ave., Dayton, Ohio.
Fritz, John R. (B), Jackson Steel Tube Co., 500 Weber St., Piqua, Ohio.
Garber, Earl M. (C), Hobart Bros. Co., Main St., Troy, Ohio.
Gerber, Charles H. (C), 214 Lonsdale Ave., Dayton 9, Ohio.
Gruell, Herbert O. (B), Dayton Fab. Steel Co., 1300 E. Monument Ave., P. O. Box 85, Station A, Dayton 3, Ohio.
Hausfeld, Ben (B), Dayton Fab. Steel Co., 1300 E. Monument Ave., P. O. Box 85, Station A, Dayton 3, Ohio.
Holt, Robert N. (C), Holt Radiator & Welding Co., 37 N. St. Clair St., Dayton 2, Ohio.
Hunter, John L. (B), 506 W. Norman Ave., Dayton 6, Ohio.
Mealey, Albert J. (B), Air Reduction Sales Co., P. O. Box 923, Dayton, Ohio.

DESIGN FOR RESISTANCE WELDING

No. 13 of a Series of Bulletins on Preferred Designs for Resistance Welding Assemblies



POORLY FORMED PROJECTION

Incorrect design of punch and die results in projection that is partially sheared around the edge. Resulting weld will be weak and will tear out easily.

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Projection made according to recommended standards is not weakened in forming. Using normal machine settings, full strength welds can be expected.

Good Projection Welding Starts with Proper Design of Projections

IMPORTANT requirements of projections in sheet material are: (1) Contour should be such that the weld grows outward uniformly, from initial point or line of contact; (2) projection should be capable of supporting initial pressure before current starts to flow; (3) projection should not be partially sheared during the forming operation; (4) mass of projection should be sufficient to prevent collapse before a spot on the other surface has been heated to welding temperature; (5) no metal should splash out between the sheets when the weld is made; (6) projection should be easy to form without appreciable distortion of the sheet material.

Although some general principles of good design for resistance welding can be indicated, as in the case illustrated above, methods of preparation are frequently specialized to suit particular conditions. If you have difficulty in designing your product parts to obtain the advantages of high speed assembly by resistance welding, submit your problem to members of the Resistance Welder Manufacturers' Association, and get the benefit of their long and varied experience with both usual and uncommon applications.

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Wagner, Leslie E. (B), 7830 Reuter, Dearborn, Mich.
Woodward, Foster R. (C), Progressive Welder Co., 3050 E. Outer Dr., Detroit 12, Mich.

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Thompson, Herman L. (C), 3415 E. 28th St., Kansas City 3, Mo.
Wheeler, Wilbur F. (B), National Cylinder Gas Co., 1814 Oak St., Kansas City, Mo.

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Carson, William C. (C), 246 N. 11th St., Allentown, Pa.

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Catchpole, Keith R. (C), 3906 Brayton Ave., Long Beach 7, Calif.
Jacobson, M. E. (C), Emsco Derrick & Equipment Co., 6811 S. Alameda, Los Angeles, Calif.
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Penkunas, Joe (C), 10532 Montara Ave., South Gate, Calif.

MAHONING VALLEY

Shore, Henry (C), Research Div., Federal Machine & Welder Co., Warren, Ohio.

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Tesmer, A. W. (B), Associated Engr., Inc., 230 E. Berry St., Ft. Wayne 2, Ind.

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Kukich, Louis (B), 59 Melville Pl., Irvington, N. J.
Rhoades, James E. (C), 20 Ascension St., Passaic, N. J.
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Kochanovsky, N. (C), The Government Purchasing Com. of the Soviet Union in U.S.A., 210 Madison Ave., New York 16, N. Y.
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Thomas, Fordon C. (A), The Lummus Co., 420 Lexington Ave., New York 17, N. Y.

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Pierson, Leslie C. (C), 1154 Sumner Ave., Schenectady, N. Y.
Walsh, John S. (C), 175 Congress St., Cohoes, N. Y.

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Mullhanpt, Alfred, Jr. (B), 25 School St., Bradford, Pa.

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Wade, James R. (C), 44 S. E. 35th, Oklahoma City, Okla.

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Collins, James T. (C), 610 13th St., Pascagoula, Miss.
Nettles, George T. (C), Ingalls Shipbuilding Corp., Pascagoula, Miss.

PHILADELPHIA

Barron, Jarred M. (C), 112 Gilmore Rd., Upper Darby, Pa.
Triess, William A. (B), P. O. Box 652, Pottstown, Pa.
Denny, Gerald R. (C), 1717 Graham Ave., Windber, Pa.
Seran, P. N. (B), Beech St., Cheswick, Pa.
Russell, Byron R. (B), 1205 N. W. Marshall, Portland, Ore.
Coles, Donald R. (B), Westinghouse Elec. Corp., 3451 E. Marginal Way, Seattle 4, Wash.
Gallaher, Morgan H. (C), 2507—14th So., Seattle 44, Wash.

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Oliver, Joseph (C), 1830 Clifford Ave., Rochester 9, N. Y.
Ryan, Wendal F. (C), Methods Dept., Gleason Wks., 1000 University, Rochester 3, N. Y

ST. LOUIS

Horneyer, Lee H. (C), 7 N. Grand Blvd., St. Louis 3, Mo.

SAN FRANCISCO

Carmody, Thomas H., Jr. (C), McGraw-Hill Pub. Co., Inc., 68 Post St., San Francisco 4, Calif.
Ebert, Arthur A. (B), 881 Sinex Ave., Pacific Grove, Calif.
Hoobler, Pearl R. (B), 805 Valencia St., Apt. 3, San Francisco 10, Calif.

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Ferguson, James E., Jr. (B), 2301 Lynnfield St., Houston, Tex.

SYRACUSE

Berliner, William (F), 1111 Park Ave., New York, N. Y.

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Leifester, Leo E. (B), 919 No. Jay St., Tacoma, Wash.

WASHINGTON, D. C.

Hartbower, Carl E. (C), Naval Research Lab., Anacostia Station, Div. of Metallurgy Welding Sec., Washington, D. C.
Miller, Ralph E. (B), 710 Auburn St., Takoma Pk., Md.
Peckham, Malcolm A. (C), 3809—13th St. N., Arlington, Va.
Wagner, George R. (C), 353 N. Granada St., Arlington 1, Va.

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Candill, L. I. (C), 528 E. Main St., Batavia, N. Y.

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Brownback, Roy (C), R. D. 4, Westwood, Pa.
Conrad, John W. (C), Lukenweld, Inc., Coatesville, Pa.

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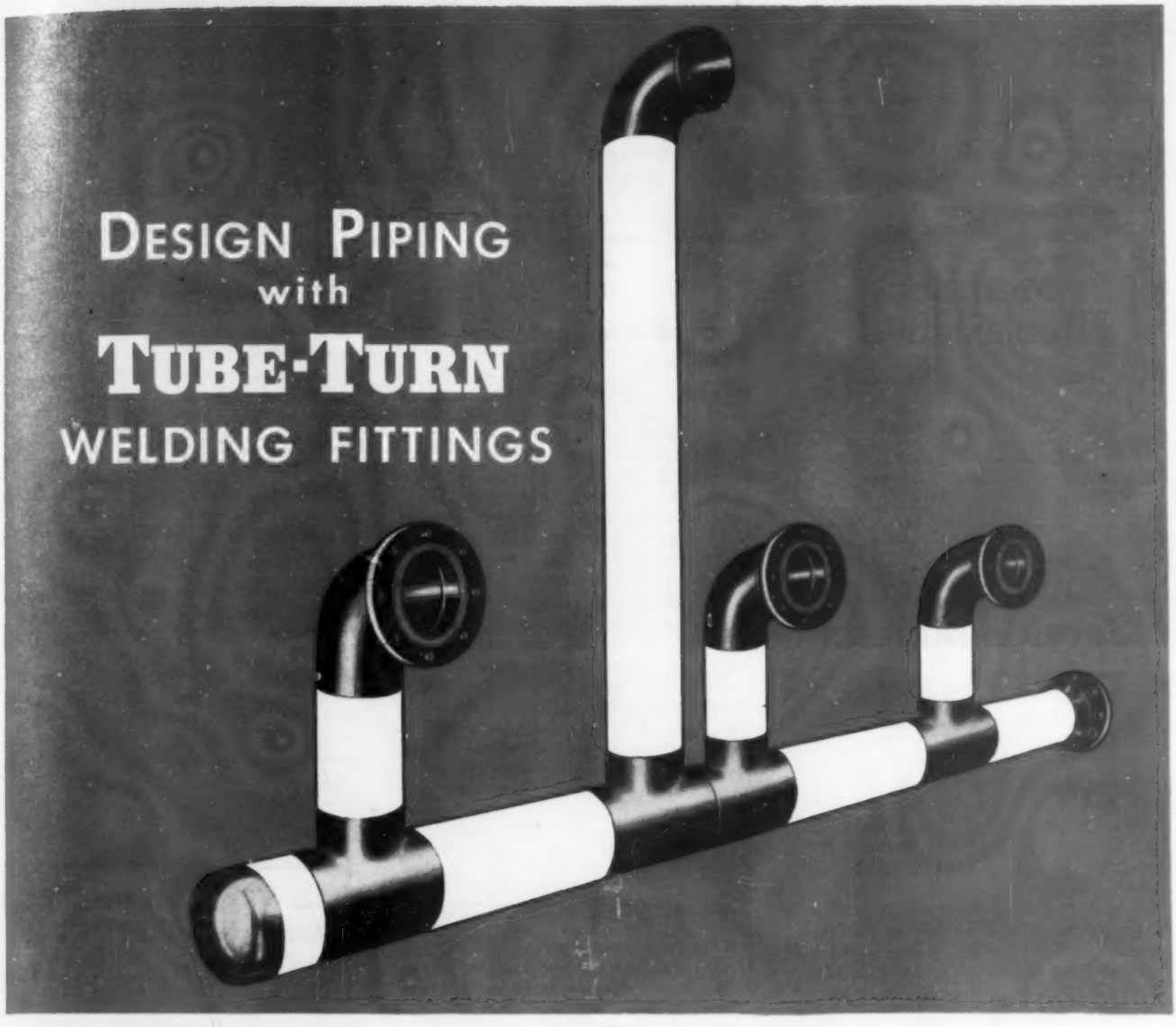
Dunlop, Albert Victor (C), Hillside Station Rd., Netley Abbey, Hants, England.
Goldschmidt, P. (B), Belgian Inst. of Welding, 21, Rue des Drapiers, Brussels, Belgium.
Groman, Robert H. (B), P. O. Box 45, Moline, Ill.
Miller, Arthur Snowden (B), 601 Hughes Ave., Des Moines 15, Iowa.



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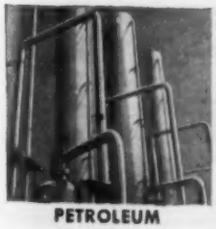
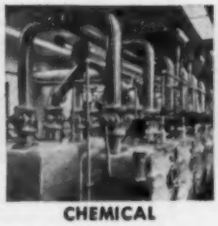

PETROLEUM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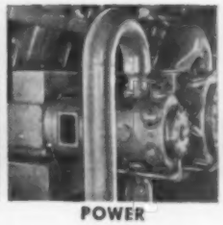
POWER

EQUIPMENT

Parsloe, George (B), Institute of Welding, 2 Buckingham Palace Gardens, Buckingham Palace, London S. W. 1, England.

Stewart, George (B), Australian Welding Inst., Australia House, Corirngton St., Sydney, Australia.

Van Der Willigen, Dr. P. C. (B), L. P. Graner, Inc., 40 E. 49th St., New York 17, N. Y.

Wiffen, William George (B), c/o Anglo Iranian Oil Co., Abadan, Iran.

Member Reclassified

During Month of January

MARYLAND

Titus, Claude R. (from C to B), Westinghouse Electric Corp., Sales Office, 118 Lombard St., Baltimore, Md.

Employment Service Bulletin

SERVICES AVAILABLE

A-514. Navy man—26, married, will be discharged this May. Two years Electric Welding Instructor and Chief Welding Instructor, Eastern Shipyard; one year Supervisor Foreman, Government Welding School; three years submarine and other shipyards electric welder; qualified for pipe, hull, pressure work and some alloys. Two years college extension; metallurgy and welding metallurgy; member A.W.S.: references: interested any field; particularly adapted instructing, demonstrating. Any locality. Permanent position only consideration.

A-515. Welding Operator and Supervisor; thoroughly experienced in modern Metallic Arc and Oxyacetylene procedures on 11 gage to 22 gage. Extensive practice on water-pressure proof containers and sheetmetal lighting fixtures. Can do lathe and sheetmetal work if needed. Good references. Able to train and supervise arc- and gas-welding department. New York, New Jersey and Connecticut preferred.

A-516. Graduate Electrical Engineer, age 30, married. Thoroughly familiar with equipment, techniques and procedures used in production resistance welding and submerged arc welding, as well as those used in metallic arc welding the nonferrous metals and alloy steels. Well versed in design of circuits for electric arc distribution systems as well as power systems for resistance welding machines. Employed as welding engineer in government service for past six years, desires responsible engineering position in private manufacturing plant or in engineering sales field. Now located in southern California, but will consider offers elsewhere.

A-517. Welding Engineer available. Age 48. Welding Superintendent for past six years with Consolidated Steel Corp., Orange, Texas, building destroyers. 10 years Senior Welding Engineer for Navy Yard. 6 years Welding Engineer with General Electric Co. Graduated from Pennsylvania State College 1916; Degree M.E.

A-518. Welder desires position. Age 30. Have had several years welding experience with shipyard before entering Navy. Worked on all-position Arc Welding, also, galvanized steel. Some experience with stainless on chrome nickel steel. In Navy did flame cutting, arc welding and small amount of gas welding.

POSITIONS VACANT

V-187. Research Fellow, half-time, to investigate strength of welded frame construction and study half-time for M.S. or Ph.D. degree in Civil Engineering. Salary, $1080 a year, together with freedom from tuition fees. Summer work available. Location, Pennsylvania.

V-188. Research Engineer—Progressive, well established company seeks engineer interested in research in the welding and metal conditioning field. Applicants should possess degree in engineering, physics, or chemistry and preferably some experience in welding, gas cutting, brazing or in related fields such as fluid mechanics or heat flow. Salary offered commensurate with experience and education. This is an excellent opportunity for a man really interested in this field to join the research staff of a modern laboratory located in Metropolitan New York area. Please answer fully.

HANDBOOK OF STAINLESS STEEL

A 100-page pocket-size (5 x 7½ x ⅛) handbook presenting practical information on 26 types of stainless steels has just been published by Allegheny Ludlum Steel Corporation, Brackenridge, Pa. It brings up to date, supersedes and amplifies the stainless steel chapters of the earlier "Handbook of Special Steels" and includes most of the data and information that is available on file-size "Blue Sheets" for the various types of stainless steel.

The handbook contains a 44-column finder chart giving analyses, properties, hot working temperatures and heat treatment of the different types and a general discussion of types and properties of stainless. This is followed by a table of corrosion resistance of four leading types of stainless to 230 chemicals and common materials.

Fabrication methods and procedures, occupying 40 pages, describe welding methods; press forming, drawing and blanking; machining techniques; spinning qualities, tools and methods; upsetting and forging; riveting, shearing, soft soldering, silver soldering, annealing and heat treating, grinding, polishing and buffing, and surface treatments, including removal of welding flux, degreasing, sandblasting, pickling, and passivating.

Stainless steel products, including plates, sheet, strip, bars, forging billets, tube stock and tubes, angles, wire, castings, forgings, and clad steel (Pluramelt) are described in a 20-page section. Final pages contain general tables of bar weights, weights of sheet, weights of tubes, feet per pound of wire, decimal equivalents of fractions of an inch, and temperature conversion.

BACK NUMBERS WELDING JOURNAL

The AMERICAN WELDING SOCIETY is short on some of the back issues of THE WELDING JOURNAL. Those members who have copies available of the issues indicated below who have no further use for same will be conferring a favor upon the society if they will send them in.

The issues which are lacking are: April to August, 1937, incl.; December 1937; February and March 1938; January 1939; February, May, and December 1940; January and February 1941; October 1942.

AMERICAN WELDING OFFERS MOTOR FRAME BULLETIN

The application of welding to the manufacture of a.-c. and d.-c. motors of both fractional and integral horsepower is described in a bulletin prepared by the American Welding & Manufacturing Co., Warren, Ohio. Illustrated, the bulletin covers arc and flashwelding of simple ring and complex specialized frame types, and enumerates characteristics and economies obtainable.

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